MODERN BUILDINGS: THEIR PLANNING CONSTRUCTION & EQUIPMENT

EDITED BY G.A.T. MIDDLETON, A.R.I.B.A.

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THEIR PLANNING, CONSTRUCTION AND EQUIPMENT

BY

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"THE PRINCIPLES OF ARCHITECTURAL PERSPECTIVE" "SURVEYING AND SURVEYING INSTRUMENTS"
ETC. ETC.

ASSISTED BY A SPECIALLY SELECTED STAFF OF CONTRIBUTORS

PROFUSELY ILLUSTRATED

VOL. I

PART I. OFFICE PRACTICE AND DRAUGHTSMANSHIP
PART II. THE PLANNING OF COTTAGES AND COUNTRY HOUSES
PART III. ORDINARY CONSTRUCTIONAL DETAILS

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MODERN BUILDINGS

VOLUME I

PART I

OFFICE PRACTICE AND DRAUGHTSMANSHIP

CHAPTER I

GENERAL INTRODUCTION

MANY books have been published upon Building Construction, and many others, mostly of an historical character, upon the Planning of Buildings, but none, so far as I am aware, in which planning and construction, which go hand in hand in practice, are treated correlatively. Yet in their severance there is material loss. In building work it is essential that that which is planned should be capable of being constructed, and at the same time it is necessary that the construction should be suited to the plan.

A book which accepts this statement as its primary axiom is necessarily a large book, covering an enormous amount of ground, and its preparation is a task which it would be beyond the capacity of one man to accomplish within any reasonable time. Yet writing this Introduction, contrary to custom, when the work has scarcely been commenced, I am hopeful of producing such a book within two years, with the assistance of a staff of writers and draughtsmen whom I have selected from personal knowledge of their capabilities rather than from their existing reputation, and with the co-operation of other architects who may be kind enough to allow me to illustrate their designs.

In scheme, the book is intended to appear in Six Volumes, each divided into three parts which shall more or less relate to one another. Thus the First Volume, to which this is attached, deals with General Office Practice and Draughtsmanship in the first part, the Planning of Cottages and Country Houses in the second part, and with ordinary Constructional Details in the third part.

The Second Volume will have its first part devoted to Town Houses of all descriptions, its second to Specification Writing and Quantity Surveying, and its third part to Domestic Finishings and Fittings. In the same way the Third Volume will deal in its first part with the plans of Schools and Hospitals, its second and third parts being devoted to the consideration of Heating, Ventilating, and Lighting, and to Professional Practice in such matters as Light and Air Cases, Dilapidations, etc.

The same idea will be further developed in the later Volumes, of which the first parts will be devoted to the plans of public buildings, such as Municipal Offices, Baths, and Libraries, to Warehouses, Ecclesiastical Buildings, and miscellaneous special buildings respectively, and the second parts to some special branch of construction naturally relating to such buildings; while special sections will be added upon Colonial architecture and building construction as practised in Canada, South Africa, and Australia.

In the first parts of all the Volumes an endeavour will be made to select for illustration typical examples of the best modern English work, arranging them, so far as may be possible, in a sequence which shall be comprehensible. Perhaps in no country and in no age has life been so complex as it is in England at the present day; certainly nowhere else and at no other period of the world's history have the complex needs of a complex life been so admirably met in the buildings. The science of planning, like most other sciences, has

been developed very highly during the last hundred years, and is still developing. As a general rule this development has been unconscious at first, and has gradually become conscious and systematised as certain architects have become specialists upon some one or other class of building, and have impressed certain ruling principles to which they have been devoted upon their contemporaries. Thus different recognised systems or schools of planning have arisen, especially for large and more important buildings. These it is hoped to illustrate in turn, describing and comparing them so far as may be possible, in the hope that further development may result on scientific and well considered lines.

As planning has developed, so has construction not lagged behind. Where at one time rules and precedent sufficed, reasons and principles are demanded now. The introduction of new materials, the development of new forms of plan, the gradual elucidation of the scientific principles underlying the construction of a healthy and convenient building, have all tended to the evolution of new methods of construction. Without omitting that which is stereotyped by custom—beginning, in fact, with the veriest elements of construction—an effort will be made to foster the consideration of principles, and so enable the constructor to meet each new demand upon his skill in a logical manner, not binding him in fetters to that only which he has done before, but training him to think out each problem by itself. With this view, in addition to illustrating ordinary cases, more difficult problems and occasionally alternative solutions of the same problem will be given and discussed.

Model Specifications will be added to some of the Volumes, specially prepared in accordance with one or other of the illustrated plans. They are not intended necessarily to be followed in detail, but are given as general guides to the practice of specification writing, either for simple or for complicated work.

SUPPLEMENTARY INTRODUCTION

Since the above words were written several months have elapsed, and now, on the eve of the production of the First Volume, it is possible to express my thanks to the many architects of note who have kindly placed plans of the buildings which they have carried out at my disposal for purposes of illustration. By their aid it has been possible to render the earlier part of each Volume, so far as the book has yet been proceeded with, fairly representative of modern planning; and while each has been individually thanked privately, I think that this public acknowledgment is also their due.

No less am I indebted to my many collaborators in the literary work, to the draughtsmen who have prepared the numerous illustrations, and to the manufacturers and merchants who have allowed me to illustrate and describe their specialities. To each and all of them I tender my most hearty thanks.

A serious attempt has been made to render the book a thoroughly comprehensive one upon all matters connected with ordinary building practice, other than such as depend only upon taste and a knowledge of architectural styles and details. To have included these in the same series would have increased the Volumes or their number beyond all reasonable limit; but at least it is hoped that what has been included has been well done, for no pains have been spared upon the part of either the contributors or the illustrators, who have all done their best to produce a thoroughly reliable work.

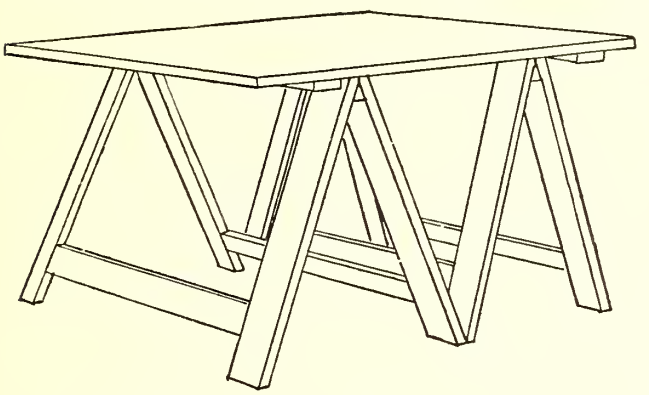
G. A. T. MIDDLETON.

CHAPTER II

DRAWING INSTRUMENTS AND MATERIALS

For the proper production of architects' drawings it is essential to be provided with well-selected instruments and materials, in perfect adjustment, and properly arranged. An expert draughtsman will, certainly, produce good work under all sorts of unsatisfactory conditions, but for the inexpert to so handicap himself is to put himself to great disadvantage and to retard his progress.

As most men stand when drawing, the Drawing Table should be between 32 and 40 inches higher, and



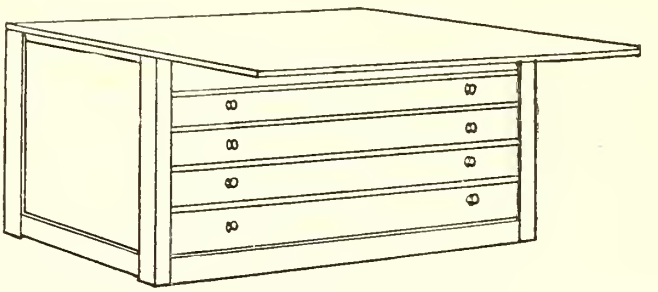
Drawing Table on Trestles.

Fig. 1.

broad enough from back to front to take the largest drawing board which is likely to be used. In many offices the "tables" consist of nothing more than a pair of trestles with a large board resting on them (see Fig. 1). This arrangement covers a good deal of floor space which cannot be otherwise utilised, but the whole thing can be readily removed and folded up against a wall if necessary.

Another form of table, much used, is one of which the under portion is formed into a nest of shallow drawers for the reception of drawings and paper. The top should, however, project considerably in front of the drawers, to give knee space, especially when sitting on a high stool (see Fig. 2), but drawers of some sort are essential, and it is an economy of space to put them here. They rarely need to be more than 2½ inches deep, except that which is to contain the unused paper, but ought to be encased on all sides, with cupboard doors to the front, so as to exclude dust; and each should be labelled with the name of the building the drawings relating to which are contained in it. The drawers should be of such sizes as will contain comfortably the drawing papers most generally used in the office.

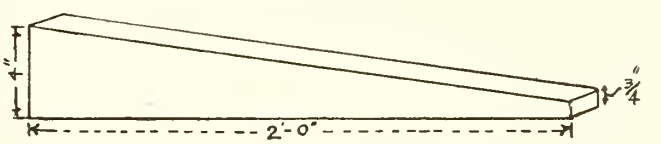
There are several patent drawing tables made with sloped or adjustable tops, but the plain flat table is as



Chest of drawers & drawing table combined.

Fig. 2.

good as any, as pencils, etc. will not roll off it as they will off a sloped surface, while the drawing board can be sloped at any desired angle by inserting small supports under it—such as 4-inch cubes of wood or specially made fir wedges (see Fig. 3).

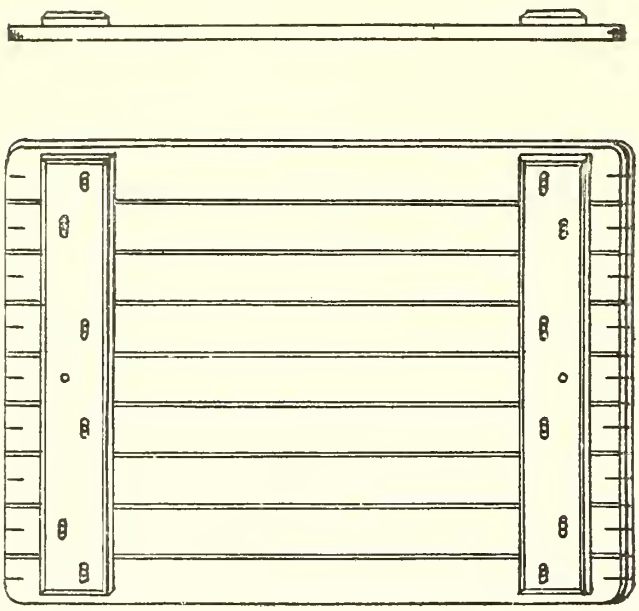


Slope block for drawing table.

Fig. 3.

It is a very common practice to place the drawing table directly in front of a window, but this is exceedingly bad for the eyesight, especially if sunlight be admitted—though generally a window is chosen which faces north, or nearly so, if there be the opportunity of selection. In any case the light, impinging on the white drawing paper, is reflected to the draughtman's eyes, causing in time a species of blindness. It is better, therefore, to place the table sideways to the window, with the light a little forward, and preferably upon the left-hand side, so as to cast no shadow either from the body or the hand upon the work. Any artificial light should be similarly placed for similar reasons—or green glasses would in course of time have to be worn.

Drawing Boards are almost always made of Canadian pine, a soft wood which warps little and shrinks evenly. Common ones are merely clamped at the edges, but those in most general use are made as shown in Fig. 4. The angles are rounded so as to avoid splitting, while the effects of warping and shrinkage are minimised by broad and deep saw-cuts from end to end along the back, alternating with short saw-cuts through the edges at the ends—where a strip of ebony is inserted—while the backs are clamped with mahogany battens attached with brass screws working in brass slots.

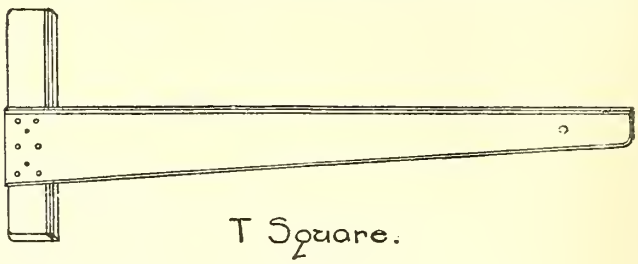


Drawing Board.

Fig. 4.

The principal requirements are perfectly straight edges and freedom from warping. It is sometimes useful to be able to work from two edges which are known to be at right angles with one another, but this is not essential. Surface warping is easily detected and remedied with the plane; but a twisted edge is less discernible. It should be tested for occasionally, as any inaccuracy may affect a drawing to a considerable extent.

A good T-square should have a bevelled edge and a tapering blade, balancing well when in use. This can only be tested by experiment, but a long straight blade is almost sure to drag. Many are made of pear-wood, which is light but easily damaged, so that the best are of mahogany with a working edge of ebony (see Fig. 5). The edge of the blade should be exactly at right angles with the cross-piece, to the face of which it should be screwed, so that in work the cross-piece does not rise above the surface of the drawing board. Experience will show that comparatively few T-squares retain the exact right angle between cross-piece and blade for any length of time; and this is of



T Square.

Fig. 5.

little account so long as the same T-square is employed on the same drawing, all lines drawn by its aid being parallel if the edge of the drawing board is true. If, however, another T-square be applied to the same drawing without altering its position on the board, and either or both these T-squares be inaccurately set, the lines drawn with the aid of the one will not be parallel to those drawn with the aid of the other. Consequently, so long as the drawing remains pinned in one position on a board, all the work done upon it should be by the aid of the same T-square; or, if T-squares are changed, the paper should be re-set to correspond.

A T-square is likely, in careless hands, to have its working edge chipped or notched. It is then necessary to take the blade and cross-piece apart and have the edge reshot; but it is much better for this necessity not to arise. An ebony edge will not get damaged in this way very readily unless it be actually cut, by using it as a guide for a penknife when cutting paper. This should never be done—nor should paper be cut on the face of a drawing board, which in this way is soon scarred and rendered uneven. It is best to draw pencil lines where paper is to be cut, and then to remove it from the board and cut it on the top of the drawing table, using the *back* of a T-square, and not its working edge, as a guide.

Drawing boards and T-squares are made to standard sizes to suit the recognised sizes of drawing paper, the comparison being as follows:—

Name of Paper.	Size of Paper in Inches.	Size of Board in Inches.	Length of T-square from Cross-piece to end of Blade in Inches.
Half Imperial . .	20 × 15	23 × 16	24
Imperial . . .	30 × 22	31 × 23	31
Double Elephant .	40 × 27	42 × 29	42
Antiquarian . .	53 × 31	54 × 33	54

An even larger paper, 72 by 48 inches, known as "Emperor," is also made by Joynson, but neither

this nor "Antiquarian" is much used, continuous paper, obtainable in rolls 50 yards in length and either 30, 40, 54, or 60 inches wide, being preferably employed in offices where large drawings are likely to be required.

Drawing Paper. It is well recognised to be false economy to employ any other than thoroughly good paper for contract and show drawings, and the papers almost invariably used are either :—

For fine pen-and-ink work, Whatman's "Hot pressed" *or* Joynson's "Smooth."

For general contract drawings with colour, Whatman's "Not" *or* Joynson's "Cold pressed."

For artistic colour work only, Whatman's "Rough" *or* Joynson's "Artist's Rough."

These can all be obtained in any of the above sizes, and of several different thicknesses, known by weight.

Only "insides" sheets should be used for good work, as "outsides" are liable to defects, such as soft absorbent patches which take colour badly, which cannot be detected till colour is applied.

The right side to use is that which shows the water mark, usually the maker's name, correctly when held up to the light.

For ordinary office use, such as the preparation of sketches or of details, there are many papers to select from, the slightly absorbent, buff-toned "cartridge" being perhaps the most popular, though many prefer the harder "web" or the thinner "detail" papers. When selecting, the best thing to do is to obtain samples, which any dealer will supply, and to test them with pencil and rubber, to ascertain whether pencil marks are removable from them; and with a colour wash to discover if they are free from blotches.

Tracing Paper is obtainable either in sheets of the same standard sizes as drawing paper, or in rolls, the latter form being much the more convenient for office use. Many different widths are made, varying between 28 and 60 inches, while the lengths most usually found in each roll are 20, 21, 22, and 50 yards. It is necessary to consider both width and length when comparing the prices of various papers per roll, and it is also advisable to select such a width as will not cut greatly to waste. Thus in an office in which almost all drawings are made on Double Elephant or Imperial paper there is little waste on tracing paper 30 inches wide, and much on that which is 40 inches wide—which shows a wide margin to Imperial paper whichever way it is cut; the tendency of most young draughtsmen being to throw away the surplus rather than to use it for odd purposes.

In selecting tracing paper it is necessary to keep in mind the purpose for which it is required. If it be for pencil sketching and the elaboration of plans in pencil, a tough paper is needed which will permit the rubber to be used with freedom, while it should be as transparent as this condition will permit. If fine ink line drawings are to be made for subsequent copying by sun process, a very smooth and transparent paper is needed. On the other hand, toughness is the principal requirement in a paper to be subjected to rough handling by workmen on a building, and whiteness of colour if the drawings made on it are to be reproduced by photography for purposes of illustration. All tracing paper turns yellow and becomes more or less opaque with age.

Tracing Cloth, which is made of linen rendered transparent by coating it with some mucilaginous substance, is made either 18, 27, 30, 36, 40, 43, or 54 inches wide, in rolls which almost invariably contain 24 yards. Some is glazed on both sides, but most of it is glazed on the face and dull backed. It is largely used for tracings which have to stand the test of hard wear, but unfortunately is not reliable in the matter of scale, as it shrinks considerably when drying after being coloured.

In most offices, though not invariably, ink lines are drawn on the glazed face, into which powdered chalk has first been well rubbed with a piece of blotting paper and then dusted off; while colour is, as with tracing paper, applied on the back, which is best also chalked first in a similar manner. Indian ink can be removed from either surface by ink-eraser, carefully used.

Tracing cloth turns an opaque white if water is applied to it; and if boiled and washed can be converted to the original linen from which it was made, no sign of any drawing which may have been made upon it remaining after the process.

Rubber should be very carefully selected. The pure bottle indiarubber is now very seldom seen, as it is too soft and slimy to remove pencil marks perfectly, and it leaves smears on the paper also. Much that is sold is similarly too soft except for removing the marks of very soft pencils very softly applied, crumbling up in use; while other is so hard and gritty as to remove and roughen the surface of the paper to which it is applied, and therefore is only useful for the removal of ink lines or colour. For general office use it would possibly be difficult to improve on Wolf's or Halden's, square and flat cakes being best.

Drawing Pins must be thin enough at the edges for the T-square to slip over them readily, and yet thick enough in the centre for the pin to be firmly attached to the brass head. If the head be of soft brass it is likely to give way when pressed home, with the result that the blunt end of the steel pin runs into the thumb of the user. The wound made is a troublesome and painful one, which can be avoided by selecting only good pins of hard brass or German silver, and these are not expensive.

The two forms which are in most general use are those lettered A and B in Fig. 6, the dome-shaped head (A) being the best for large pins, while the flat head with bevelled edge (B) is most convenient in smaller sizes. Both sorts are made in several sizes, from $\frac{1}{2}$ to $\frac{7}{8}$-inch diameter; but the larger pins are

far the best, gripping the paper well, easy to remove, and not very easily lost.

The pin lettered D in Fig. 6 is better still. It is of gimlet form, and makes a very small hole either in paper or in board, while the head, besides having bevelled and milled edge, has four holes through it, to facilitate its being inserted or removed by a twisting action with the thumb. It is known as the "Grip."

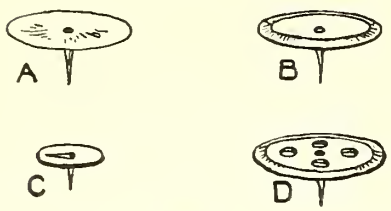


Fig. 6.

The small pins, lettered C, are stamped out of solid nickel-plated steel, head and pin being in one piece. They are very cheap, and are useful for the temporary attachment of small tracings rather than for large work.

Set-Squares (see Fig. 7) are small triangles of which one angle is necessarily a right angle. The other angles may vary, but for most work it is sufficient to keep one having each of these 45 degrees, and another having one angle of 30 and one of 60 degrees. Those of the forms shown as A and B in Fig. 7 are generally made

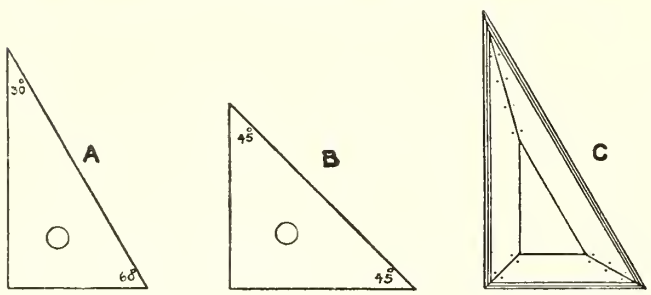


Fig. 7.

of pear-wood, vulcanite, or transparent celluloid. Of these, pear-wood is generally preferred, for it is clean and cheap, while vulcanite collects dust and rubs it into the paper, and celluloid buckles. The framed form, C, is generally made of mahogany, with bevelled edges, often of ebony; but it is exceedingly liable to lose its shape, and a set-square whose angles are incorrect is worthless and must be destroyed.

A set-square having a movable arm which can be adjusted to any desired angle, known as a *clinograph* (see Fig. 8), is also made, but as a general rule it is

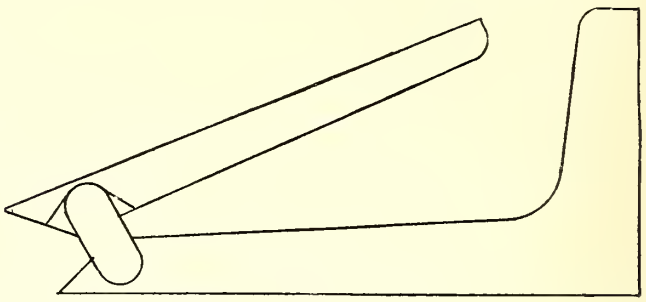


Fig. 8.

dispensed with, and parallel lines at unusual angles are drawn by adjusting the T-square on the board so as to use one of the ordinary set-squares, sliding it along the T-square as desired while holding it carefully in position (Fig. 9).

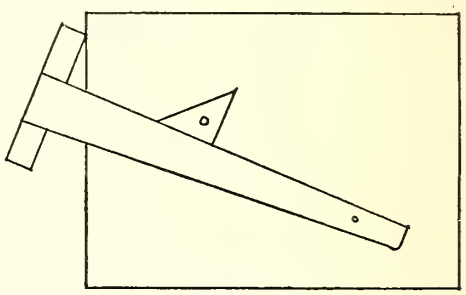
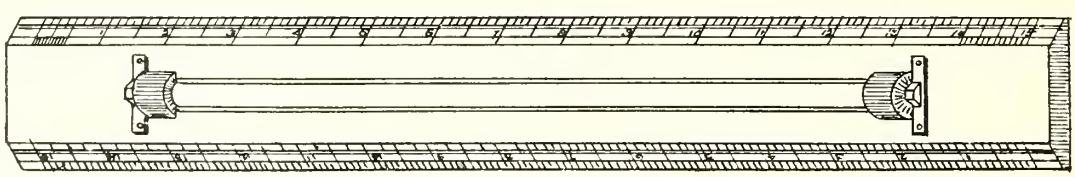


Fig. 9.

The same result can be obtained by using a T-square with a revolving head to which the blade can be clamped at any desired angle, or by employing a Parallel Ruler (see Fig. 10). This, to be of any real service, should be large and heavy, with large grooved rollers projecting but slightly below the under flat surface, and with bevelled edges. None should be purchased without first testing, as any inaccurate setting of the rollers will prevent accurate rolling, and render impossible the production of parallel lines.

A few French Curves (see Fig. 11) are kept in most offices to assist the unskilled to draw subtle curves in short lengths, little by little; but a good freehand draughtsman will generally disdain their assistance.


Parallel Ruler.
Fig. 10.

The Scales in general use for architectural work

are those of 1, 2, 4, and 8 feet to an inch, known colloquially as "inch," "half-inch," "quarter," and "eighth" scales respectively. They are to be obtained 6, 12, or 24 inches long, the 12-inch scales being generally used, engine divided with extreme accuracy on either boxwood or ivory; and while it is best to have only one scale on each edge, and that reading only in one direction, for the avoidance of errors, yet many prefer to have the

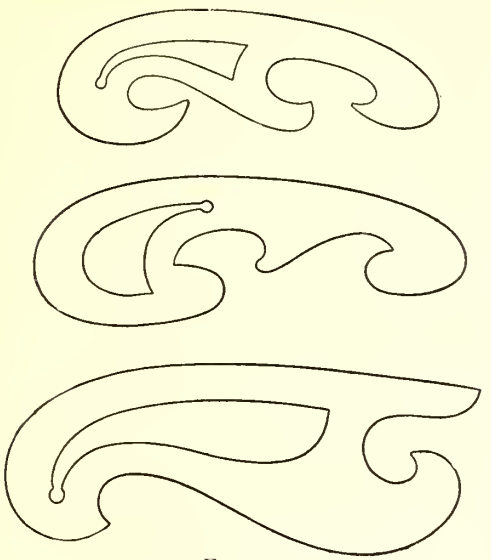


Fig. 11.

readings from both ends, and even to have several scales on the same edge (see Fig. 12). Two sections are made (see Fig. 13), of which the oval has readings on both sides, and is most convenient as a short 6-inch scale for carrying about in a rule-pocket for occasional use, as illustrated in Fig. 12, while the flat form has readings on the bevelled edges only, and is the more suitable for use on the drawing board.

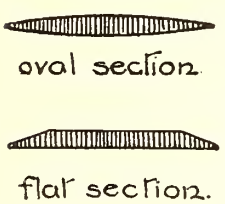


Fig. 13.

A 2-foot Rule should be carried by everybody engaged in building operations, from the architect downwards, and is most useful if it has a series of scales along bevelled inside edges. A special pocket has to be made for it, preferably in the coat of a draughtsman and in the trousers of a workman, this pocket measuring 6 inches deep by $1\frac{1}{2}$ inches wide, and being useful also for pencils and fountain pen.

Indian or Chinese Ink may be rubbed up from a stick in a palette with a little water, the rubbing being continued until the liquid begins to thicken and becomes jet black, or may be purchased in bottles ready mixed. This latter form is so convenient that it is now almost entirely used, though it is slightly more expensive; and an indelible ink, which, once dry, will not "run" when washed over with ink or colour, is as easy to obtain as the ordinary kind.

The Pencils most used are H and F for small scale general drawings, and HB and B for details, but both harder and softer pencils are used occasionally. With regard to quality, it only need be said that a gritty pencil or one which breaks frequently is a constant source of annoyance. It is economy to pay a good price for a reliable pencil.

Drawing Pens need to be selected with the greatest care, as, after the T- and set-squares, they are the most used of all the appliances of an architectural draughtsman; and they vary much. The principal requirement is a stout lower nib, which will not yield to moderate pressure against the T- or set-square; but beyond this a good pen should be hinged to open, as shown in dotted lines in Fig. 14, so as to be easily cleaned, as it always ought to be directly after it has been used, wet ink being removed by a duster and dry ink scraped off with a knife.

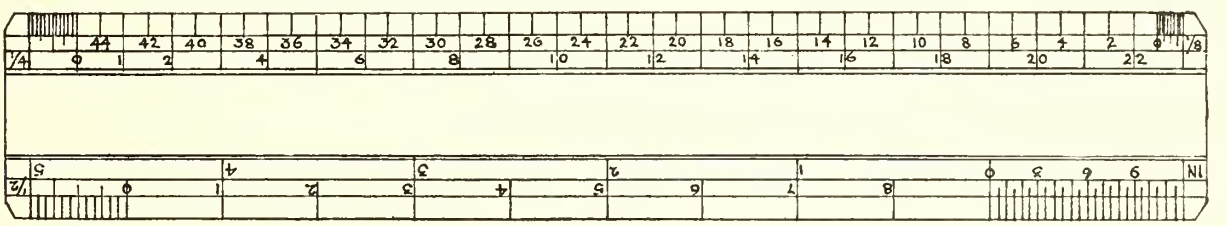


Fig. 12.

If a pen becomes blunt with use, it has to be "set" or resharpened by rubbing the *outside* of each blade gently on an oil-stone, first when open, separately, and finally when closed together, when possibly the point may need a little rubbing vertically on the stone to bring both nibs to the same length. A little practice is necessary, and a novice is recommended to watch the process in the hands of an older man before trying it himself, else he may make matters worse instead of better, and produce a pen which will scratch or cut the paper. Generally a slightly rounded and broad point is preferred for the modern thick line on good paper, but for fine work and for

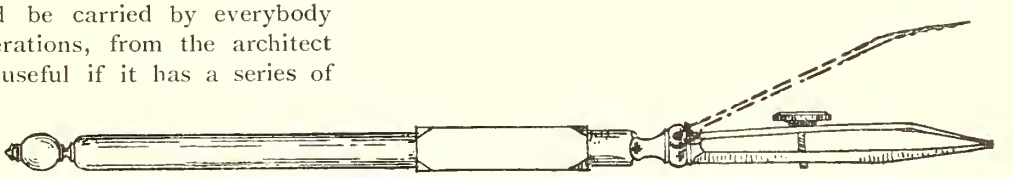


Fig. 14.

clear lines on tracing cloth a sharp and narrow point is necessary.

Compasses are of several forms, including *Dividers*, *Large Compasses*, *Bows*, *Spring Bows*, *Napier Compasses*, *Proportional Compasses*, and *Beam Compasses*.

Of these, *Dividers* (see Fig. 15) are the most elementary, consisting of two similar legs ending with

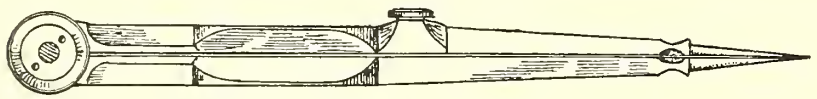


Fig. 15.

points as shown, or needles. They are used mostly for accurately measuring and transferring distances from one drawing to another. The screw at the top, which actuates a spring and enables very fine measurements to be made, is not always present, an instrument which possesses it being called a *Hair Divider*. The hinge joint can be tightened up if it works loose, by means of a key supplied with all boxes of instruments, and fitting all the compasses in the box.

Large Compasses (see Fig. 16) have either steel or needle points, needle points being shown in the

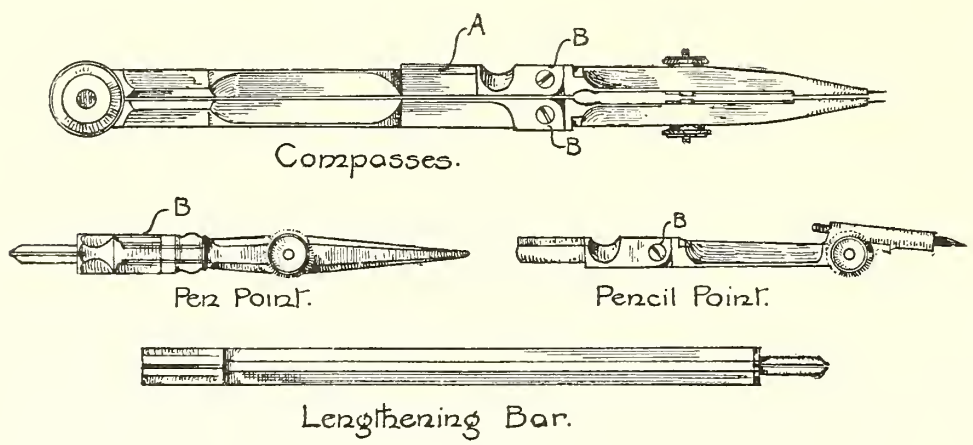


Fig. 16.

illustration, so that they may be used as dividers, while one of the points may be removed from the socket at A and replaced either by the pen point, pencil point, or lengthening bar. There are knuckle joints at B, so that needles, pen, and pencil can all be brought vertically to their work, as shown in Fig. 17, in which the compass is shown with lengthening bar and pen point inserted, ready for striking a large circle. Needless to say, it requires some skill and steadiness of hand to draw such a circle accurately without slipping; and in fact it is best, when the lengthening bar is inserted, to use both hands, one holding the needle point on the centre while the other guides the pen.

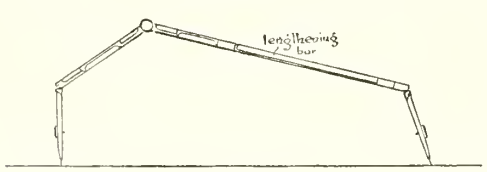


Fig. 17.

Bows are small compasses (Fig. 18), made separately for pen and for pencil having a holder, A, beyond the joint to enable small circles to be struck at a single sweep. They are more used than any others, and the only respect in which they require special care is in keeping the pencil the same length as the needle point. The pencil may, if preferred, be cut to a chisel edge instead of a point.

Spring Bows (Fig. 19) are intended for the very smallest circles. They are made of fine steel, and act like a spring, tending to open out against a small screw nut, by means of which they can be adjusted to the nicest accuracy, the extent to which they are allowed to open remaining constant for any desired length of time. It is necessary that the screw bolt should pass through a *slotted* hole in the needle arm, else the bows will open in a jerky manner.

Napier Compasses are made to fold, so as to be carried in a pocket, and are of many different forms; but they are unfortunately liable to work loose at the joints, and so are not reliable for accurate work.

Proportional Compasses (Fig. 20) open at both ends round an adjustable centre screw hinge working in a long slot. They are made with points only, and the centre screw can be so set that the distances between the long points are equal to those between the shorter points, or two, three, four, or more times those distances, as may be required. They are consequently of great value for enlarging or reducing drawings in exact ratio—and by varying the scales engraved upon

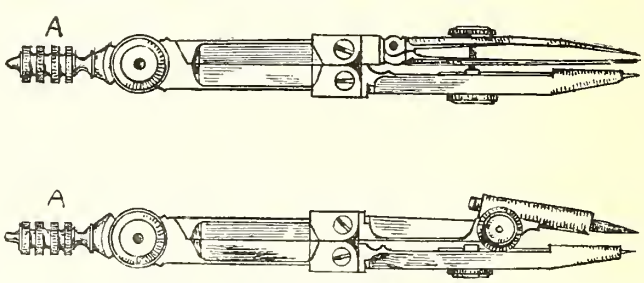


Fig. 18.

them they can be adjusted to give the proportions either of lines, areas, or solids.

Beam Compasses (Fig. 21) are quite different from

the other forms, and are intended for striking very large circles only. They consist of two separate legs,

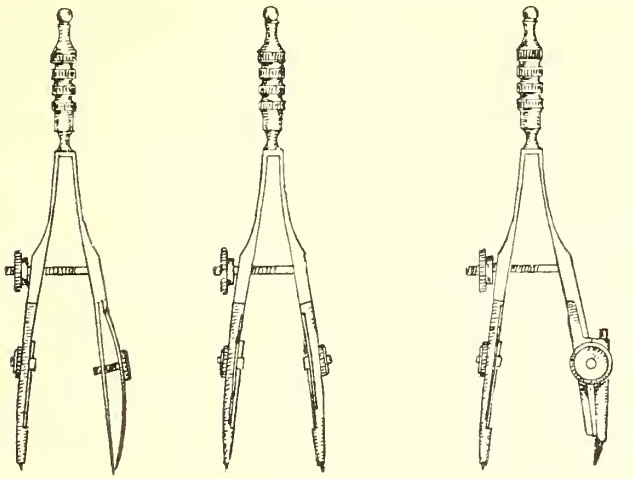


Fig. 19.

each of which can be clamped, by means of metal plates and a screw, to a long lath or the blade of a T-square. Each leg can be fitted at will with either needle point, pen, or pencil, and to one at least there

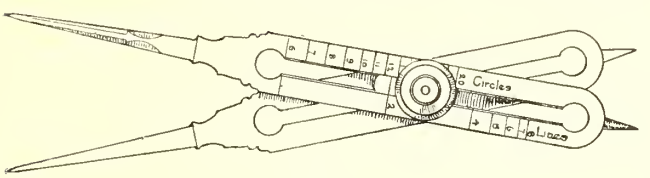


Fig. 20.

is a travelling thread worked by a mill-headed screw A, to give absolutely exact adjustment of distance. In use, especially with circles of really large radius, it is necessary for one person to hold the

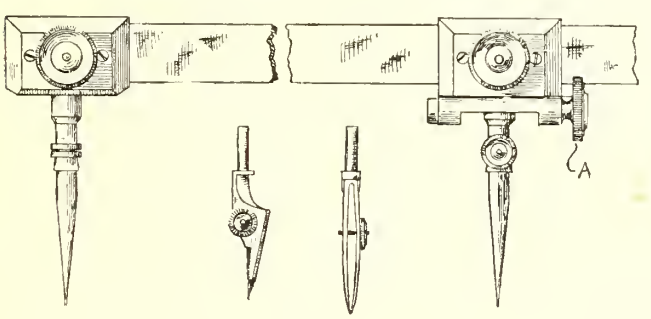


Fig. 21.

needle on the centre, while another guides the pen or pencil.

A Pricker is another important instrument, though it is nothing more than a needle with a handle to it, for use when transferring drawings from one sheet of paper to another, by placing the sheets over one another and pricking the principal points through from the upper to the lower sheet.

A Protractor is an instrument for measuring angles on a drawing with more or less accuracy. Most of those supplied with sets of instruments in boxes or cases are made of horn or ivory and are quite unreliable. Somewhat heavy circular protractors made of brass (see Fig. 22) are those upon which most

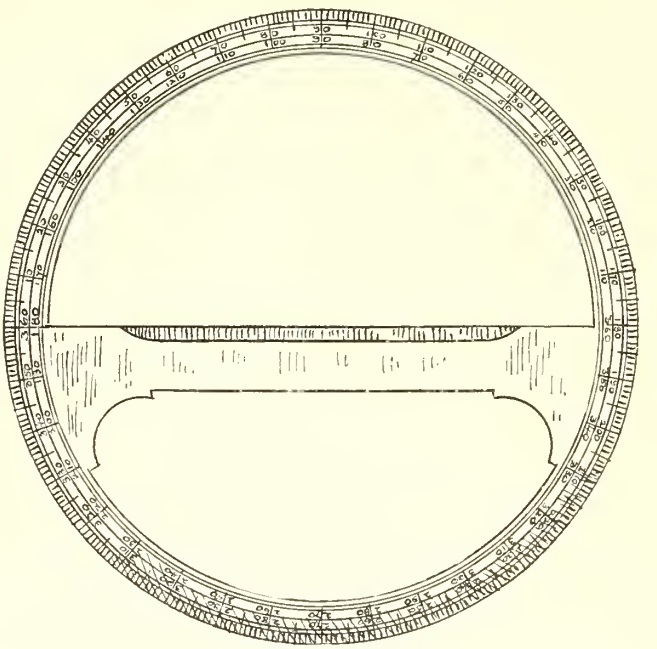


Fig. 22.

dependence can be placed, though if very close readings are required they must be supplied with an extending revolving arm, with a vernier scale on it like that on a theodolite, with similar clamp and tangent screws for accurate adjustment.

Drawing pens, pricker, compasses, bows, spring bows, and protractor are frequently bought in cases or boxes, but there is always some risk that a set thus purchased may contain one imperfect instrument or

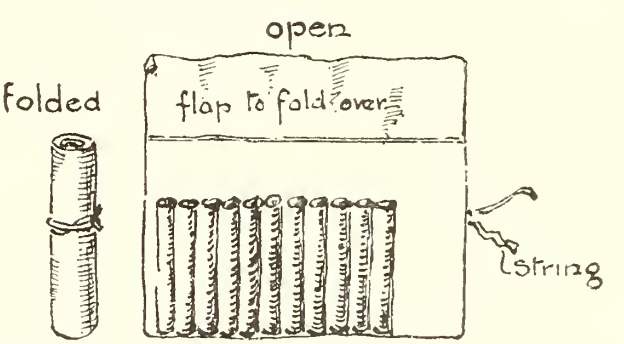


Fig. 23.

more, and many draughtsmen prefer to purchase singly in consequence, keeping their instruments in a roll of chamois leather pockets (see Fig. 23) such as can readily be made at home.

CHAPTER III

THE PREPARATION OF WORKING DRAWINGS

(Contributed by R. W. Carden, A.R.I.B.A.)

The subject of working drawings is one to which a draughtsman cannot give too much attention, for accurate plans and details are absolute essentials for the production of good building. It is well to bear in mind that working drawings *are* working drawings and not pictures. They should merely aim at being accurate diagrams setting forth exactly the work which is required to be done, with such dimensions as are necessary clearly figured on the drawings, and the conventional colours employed to indicate materials whenever they will aid in expressing the architect's intention. Anything beyond this is not only a waste of time, but is likely to mislead the contractor and his workmen. Violet shadows and brown ink may possibly appeal to the client, especially when used in conjunction with pale green lettering, but the builder is rarely susceptible to "art," and merely sees in the drawings put into his hands something which will explain and supplement the specification.

In all such drawings the utmost care and cleanliness is required, for dirty T-squares and set-squares mean too much use of the indiarubber, and too much indiarubber means spoiling the surface of the paper, and leads to blurred lines and colours. Beyond the primary precaution of cleaning all instruments, it is advisable to so set out drawings that pencilling and inking are begun at the left-hand top corner of the paper, and the work continued across and downwards, so as to avoid blurring by repeatedly passing the T-square and angles over finished portions of the drawing.

For all ordinary purposes working drawings may be divided under three heads: drawings to the scale of $\frac{1}{8}$ inch to a foot, drawings to the scale of $\frac{1}{2}$ inch to a foot, and full-size details. Of these by far the most important are the first, as they constitute the chief contract drawings and include plans of each floor (and of roof and foundations very frequently also), elevations of each front, and at least two sections through the whole building. Among the contract drawings should be included a block plan—to a convenient scale, or as required by the local regulations—and drawings to the scale of $\frac{1}{2}$ inch to the foot of any portion of the building which may seem to require more detailed explanation. These latter, however, come under the second head.

Should the building be a large one, it will be found advisable to prepare the contract drawings on canvas backed paper, and to have them bound round the edges with silk ribbon. It is surprising the amount of knocking about and rough handling these drawings have to suffer during the progress of a contract. Concerning the actual drawings, there is little to say beyond emphasising the necessity for careful thought and accuracy. It is useless to place a 14-inch wall and fireplace on the first floor with only a $5\frac{1}{2}$-inch partition to carry it on the ground floor, and it is wisest to build on paper as the contractor will in material, beginning from the foundations and working carefully upwards, drawing a plan, section, and elevation in turn until the whole is complete in pencil. For instance, fireplaces below must find room enough in the chimney breasts above for their flues, and stairs must be sufficiently given in detail for no doubts to arise as to headroom.

The principal object of $\frac{1}{8}$ scale drawings is to present a general scheme of the whole work with all the sizes of the various rooms, positions of openings, thicknesses of walls and chief features. It is of the utmost importance, therefore, that all the dimensions be fully worked out and figured clearly on the plans. All part-dimensions, when added together, must agree with the total through-dimension, and these are probably best worked out partly by measurements on the plan and partly by calculation on waste paper. For instance, if a house have parallel sides each set of dimensions right across must total the same; but if each part dimension were figured on exactly to what it appeared to measure on the plan errors would undoubtedly arise, as with a scale of $\frac{1}{96}$ full size it is impossible to plot accurately to every half-inch, so that these dimensions have to be adjusted and corrected by the known through-dimension. These $\frac{1}{8}$ scale drawings are inked in and fully coloured up, whether the parts shown be in plan, section, or elevation, and in the latter the courses of brick or stone are also frequently indicated, but not in such a manner as to mislead the builder into taking the lines so added to the drawing to mean something else. The section lines should be very clearly and correctly marked on every plan, and are best represented by a bold line of alternate dots and dashes; for if an ordinary solid line is used it is liable to confuse the plan and suggest a difference of level. All the dimensions—which, as already said, must agree always with the totals—should be printed on in red ink, with limiting lines to show clearly and exactly how much of the plan is included in the given dimension.

The "$\frac{1}{2}$-inch details" include almost every portion of the building, and a good set of $\frac{1}{2}$-inch working draw-

ings would illustrate every door, window, staircase, roof-truss, gable, skylight, etc. etc., contained therein. As already hinted, some of the drawings to this scale are frequently made part of the contract drawings, so that important features are irrevocable in nearly all their details before the building is begun. This is of the utmost importance always, but especially so when an architect is obliged to give the work to a contractor who is known to have cut down his estimate to a ridiculously low figure. In such a case the contractor will very possibly be always on the watch for omissions from specification or contract drawing to enable him to claim extras, and so make up by profit on these for lack of profit on the contract. If, however, he is made to sign, among the other drawings, a ½-inch drawing of one bay of the front, or of any important panelling in the hall, or a marble terrace or whatever elaborate features there may be included in the work, it will deprive him of half his opportunities for claiming extras, as naturally he cannot dispute his own signature.

All ½-inch details other than those just referred to are drawn in conjunction with the full-size details, and hold the same relationship to them that the ⅛-inch scale drawings do to the ½-inch details. They serve, that is, as a key diagram, showing in miniature the whole of the feature detailed, and give the principal dimensions of the same, and the relative positions of all the parts, mouldings, etc. The leading proportions for the ½-inch detail are taken from the ⅛ scale drawings, or if that portion of the building be already built in the rough materials it is safer to make these measurements on the actual work. From whichever source derived, these few heights, widths, and projections are sufficient for the setting out of the ½-inch drawings, and as half an inch to the foot is a scale in which even small mouldings can be indicated, the draughtsman is now able to see the whole feature in its grouping, and can compose his mouldings and decide on the points he wishes to emphasise with ornament. He can judge, too, whether his mouldings should consist of a few large or several small members, settle their projection, decide on the depth of his friezes, and in fact establish the whole of the feature, excepting only the actual form of the mouldings and carvings. The drawings for these mouldings and carvings are drawn full-size, and are the full-size details which have already been referred to.

Those ½-inch drawings which are intended to be included in the contract should be drawn on paper, inked in and coloured, but the drawings which are supplied during the progress of the work are merely drawn out in pencil, and tracings made in ink for the builder. The full-size details are also drawn out in pencil, and ink tracings made for the contractor. This does not apply to carved work, which may be drawn out in any manner, as best suits the draughtsman's style. Carved work is generally "specified" rather than "designed" by the architect, and if the work be of an ordinary character it can be dealt with in this way, a provisional sum being allowed for it in the specification; but for more important work it is better to draw the detail out in charcoal or monochrome. It is better still to make a small model of the required work, because it is impossible to design satisfactorily on a flat sheet of paper an ornament which presents facets to every point of the compass; but whether this should be done by the architect or by the carver—who would, of course, submit it to the architect for approval—is a matter of opinion. The ordinary full-size details of mouldings require but little notice, but it may be as well to warn beginners that curves which look graceful on a drawing in section do not necessarily look so beautiful when cut in stone or run in plaster, especially if they have been drawn out with no consideration of their relative position to the point of view.

And here it may be advisable to say a few words with regard to the methodical execution of a complete set of drawings for a building from the moment when the architect and his client have agreed upon the exact arrangement of the house. There are the contract drawings to prepare and complete before they go to the quantity surveyor for him to calculate the quantities. When the bills of quantities are out, tenders received, and the builder selected, the contract drawings are signed by the contractor and the building owner. These drawings then become legal documents, and no alterations may under any circumstances be made in them, unless with the sanction of, and initialled by, both parties to the contract. The architect has to prepare, under the R.I.B.A. schedule of "Professional Practice as to the Charges of Architects," one set of tracings and duplicate specification, these being for the use of the builder. Tracings of the contract drawings should be made on cloth, and of course in every respect facsimiles of the original drawings. All other tracings may be on paper. By no means infrequently, however, especially in London offices, small scale contract drawings are first got out in pencil on small flaps of tracing paper, a separate flap being used for each floor plan, and the flaps being superimposed to secure accuracy. These are then pinned on a board and traced in ink on one large sheet of tracing paper or cloth; and from this tracing sun prints are made, as many as are needed, in black line on drawing paper or tracing cloth, one copy being coloured and signed as working drawings, and others being supplied as may be required to the contractor or for deposit with local or other authorities.

At this stage it is advisable to open a "Register of Drawings," a small book in which every drawing is entered with full information as to its purpose. Every drawing should have its serial number throughout the whole course of the work, and the book should show in parallel columns (1) the number of the drawing, (2) date when made, (3) description of drawing, (4) its scale, (5) whether on paper, tracing cloth, or tracing

paper, (6) by whom drawn, (7) to whom sent, (8) when sent, and if required, (9) how sent. This at first sight would appear to involve a great deal of extra work, but in practice it does not increase the labour of a staff to any appreciable degree. Its advantages are obvious, for the whole history of every drawing can be followed up in a moment, and no question as to where a particular drawing is ought ever to arise. The register would be as follows :—

Register of Drawings.

Number.	Date.	Description.	Scale.	P., T.C., or T.P.	By whom.	To whom sent.	When sent.	How.
1	7/2/00	Front elevation (contract drawing) . . .	1/8	P.	P. R. L.	In office . .	...	...
94	3/12/01	Drawing-room bay window	1/2 + F.S.	P.	J. W.	In office . .	...	...
95	3/12/01	Tracing of 94 . . .	,,	T.P.	J. W.	Builder . .	4/12/06	By post.
107	20/12/01	Tracing of Ground Floor plan (No. 5) . .	1/8	T.P.	P. R. L.	To..... (heating engineers)	20/12/06	By hand.

The letters in Col. 5 stand for paper, tracing on cloth, or tracing on paper ; and those in Col. 6 represent the initials of the draughtsman who made the drawing.

It must be borne in mind, however, that this register is rendered quite useless if the draughtsman — and unfortunately such carelessness is by no means rare— omits to write the name of the drawing in full and its number on each sheet. It is safest to write on the name almost before the drawing is begun, as then it is the most likely to be remembered, for the majority of drawings are finished in a hurry and handed over to be traced by a junior. The junior does his work, titles his tracing and sends it off, while the drawing, untitled and unnumbered, goes into a drawer, to lead later on to endless discussion as to what job and what portion thereof it deals with.

Most architects stipulate in the specification that on the completion of the work all drawings are to be returned by the builder. Whether this be done or not, all drawings referring to the completed building should be collected together and done up into a huge roll, docketed and put away among the records of the office.

Inks and instruments have been largely dealt with in the previous chapter, but before discussing brushes and colours it may not be out of place to say a word about the many architects' and engineers' coloured inks which are advertised as being waterproof. Probably more drawings have been ruined by falling into this snare than from any other cause. The majority of the Indian and Chinese inks are undoubtedly waterproof, but there is scarcely a coloured ink which will bear colouring over without "running." Drawings are often finished up in ink with the sections, dimensions, drains, and what not drawn on in red, blue, and green, relying on the waterproof qualities of the inks, and then, when the colour washes are laid on the inks run in such a terrifying manner as to qualify the drawing to compete with a rainbow. It is better not to use these "indelible" (?) inks until all the colouring has been done, and then, as there is no risk of "running," the ordinary colours in the colour box may be used instead. Coloured inks are in no way necessary to an architect.

The most convenient form in which to buy colours is undoubtedly that lately introduced by Windsor & Newton. These colours, which include Venetian Red, Yellow Ochre, Sepia, Lamp Black, Prussian Blue, and all the ordinary colours used by architects, are made up in hexagonal cakes about 2 inches long, and contain approximately as much colour as two and a half of the ordinary cakes. As they only cost as much as a cake and a half of the ordinary size, the saving is obvious.

The conventional colours used for 1/8 scale drawings differ in some respects from those employed for details, and there is also a general difference between the practice in London and in the Provinces.

According to the London practice, on 1/8 scale drawings brickwork in elevation is coloured very lightly with a tint of Light Red or Venetian Red, and brickwork in section by the same colours laid on more thickly. In the Provinces crimson lake is often substituted for the other reds, and this colour is also used by engineers and surveyors not only for walls, but also for plans of estates, etc. Stone is fairly universally indicated in elevation by a very pale tint of yellow ochre (or else it is left white with the courses shown by the inking in). In section it is indicated by a bold tint of indigo. On 1/8 scale drawings in London,

woodwork is represented in section and elevation by sepia, a darker tint being employed for sectional parts. On detail drawings sepia is used for wrought wood in section, and burnt sienna for unwrought wood. As has been stated earlier in this chapter, elevational parts need not always be coloured on detail drawings. In the Provinces yellow ochre is used for woodwork in elevation, and burnt sienna for sectional parts, whether wrought or unwrought. Internal or external plasterwork is indicated by a tint of yellow ochre on all drawings, but where required for details, as in mouldings and sections, purple is generally employed. This tint is best made by mixing crimson lake and prussian blue. Ironwork in section and elevation is universally represented by prussian blue, with a darker tint for the sections. It may be remarked here that all sectional parts are coloured more darkly than the same material in plan or elevation. Concrete is indicated by Payne's grey. Leadwork, the little that appears on elevations, is coloured by any blue which does not cause confusion with the other blues which may be employed in the same drawing. In leadwork details a bluish green tint should be used. Floor tiles and mosaic are coloured with a tint of crimson lake and light red mixed, while for roof tiles the same colours are employed, but often with sepia or burnt sienna added so as to more closely approximate to the actual colour of a tile. Slates are indicated by a greenish grey, which may be obtained by mixing Payne's grey and burnt sienna or indigo and burnt sienna. For windows in elevation the glass can be coloured with a light tint of either of the latter, or, better still, with a mixture of prussian blue and sepia, or prussian blue and burnt sienna. Some architects prefer to use a light wash of lamp black for this purpose. Green is hardly ever used alone, except perhaps for glass in section, and this occurs rarely. Lamp black is the best black to be obtained when walls or sections have to be blacked in instead of coloured. It is a dull dead black which can be laid on perfectly evenly, and has not the bronze-like sheen which is the drawback to the use of Indian ink for this purpose.

The colours, to recapitulate, which are required in an office for working drawings are:—light red (or venetian red), crimson lake, yellow ochre, indigo, sepia, burnt sienna, prussian blue, Payne's grey, and lamp black.

Brushes can be obtained in great variety, but the architect requires but few for office work. The most satisfactory will be found to be the sable-hair brushes in metal ferrules or tubes; and although these can be obtained in sizes from 1 to 12, the draughtsman will only need to supply himself with, say, No. 4 for filling in walls and small pieces, No. 7 or 8 for small washes, and No. 11 or 12 for large washes. Camel-hair brushes are cheaper, but the hairs lack the suppleness of sable, and do not spring or respond under the touch. Those who are used to working with sable will find it very difficult to change to camel-hair brushes, and it is a matter of universal experience that the sable brushes are the cheapest in the long run. Brushes ought to be washed out in clean water after use, the surplus water being "thrown" from the brush, and the bristles lightly brushed over the palm of the hand to bring them to a point before they are put away to dry.

This chapter would not be complete without a few words on laying washes of colour. It is scarcely necessary to say that the first step must be to carefully clean up the drawing with indiarubber so as to remove all pencil marks, and if necessary to rub the drawing over carefully with bread crumbs. Care must be taken with these, however, as the bread crumbs, if scrubbed in unmercifully, are almost as effective as ink-eraser, and can easily spoil the inking in of a drawing. If any doubt whatever exists as to the waterproof qualities of the ink, it is best to wash over the whole drawing with clean water and a large brush, drying off the water immediately on clean blotting paper. By this means the ink which would run is dissolved, and soaked up immediately into the blotting paper, leaving the drawing perfectly clean and ready for colouring. When applying large washes of flat colour it is best to elevate the top of the board so that the colour will flow more freely down to the bottom. The tint should be mixed in excess rather than too little, and care should be taken to see that the tint is very light. One is apt to misjudge the effect of a large body of the same colour from a small sample tried on a scrap of paper, for what in the sample appears to be right will often prove to be too dark when laid on in a wash. The mixed-up colour in the palette or saucer should be stirred round every time the brush requires more colour, otherwise, as many of the colours are heavy, the particles will collect in the bottom of the saucer and the tint be rendered uneven. Especially is this necessary where reds or browns and blues are mixed, for the specific gravities of two colours are so different that the particles separate, and the colour changes in tint unless frequently mixed up. The largest brush *full* of colour must be employed for large washes, and be carried right across the top of the space to be coloured, and continued downward in successive horizontal strokes across and across until the bottom of the drawing is reached: the principal point to bear in mind being that the brush *must always be quite full of colour.* Should any of the lines be inadvertently overstepped the colour may be pushed back with the finger, and the mistake rectified. When the whole space is covered with the wash, dry the brush and use it to soak off the colour, which will remain in a little pool all along the bottom of the drawing, until there is no excess of colour left. To the beginner this apparently drastic use of a veritable sea of colour is somewhat alarming, but it is the only means by which an even wash can be obtained, and with care and practice no mishap should occur, while

the largest surface can be covered with a tint so flat that it might be mistaken for the actual colour of the paper.

It is advisable in all cases, especially with drawings which may have become a little greasy, and it is absolutely necessary on cloth and paper tracings, to mix a little "ox-gall" into the colour, as this ensures the colour lying evenly. Care should be exercised not to employ too much, as ox-gall is liable to dirty the tints, particularly light washes of yellow ochre and light red.

Very frequently it happens that portions of the drawing have been scratched out with a knife and renewed. All these spots should be carefully noted mentally before the washes are applied, as the colour will soak into them more and leave a darker tint. This can be avoided by sopping up the extra colour with a small pad of clean blotting paper, and the spot should be continually "dubbed" till the tint has begun to dry and the particular portion ceases to darken. When thick colours are required to be used for a long time, such as dark venetian red for walls in section (the colouring of which may take a couple of hours on a large plan), care must be taken to keep the colour from drying in the saucer. In order to keep the tint of about the same thickness, in warm weather particularly, a drop of water should be mixed into the saucer every second or third time the brush is refilled with colour.

In making working drawing, clearness and accuracy are the chief points to aim at. In order to fulfil these requirements it is necessary to cultivate a precise and clean style of draughtsmanship, and a few words on the care of the instruments may not be out of place, as if the instruments on the board are kept clean and tidy the chances are in favour of the drawing being in the same condition.

On coming to the office in the morning, before removing the covering sheet from the board, dust it well, and after it has been taken off, dust the board, and any loose articles on it. Then, before beginning to use the T-square and angles, rub them well on a piece of rough drawing or blotting paper. This removes the pencil grit, which rapidly accumulates on them, through passing over old lines; and the operation should be repeated occasionally during the day.

Then open the instrument box and take out the instruments required, afterwards putting the box in the drawer, as if it be left on the drawing board it either becomes full of indiarubber shreds or eventually gets knocked off the board altogether by the T-square, an operation calculated neither to improve the temper of the draughtsman nor the quality of the instruments. The Indian ink, also, if being used, should not be kept on the board, for ultimately it is certain to be upset.

The modern Indian ink bottle is usually supplied with a cork having a quill in it for filling drawing pens. This looks very useful, but it is usually cut so blunt that it is difficult to fill the pen cleanly, and besides this, it does not reach to the bottom of the bottle unless the cork is jammed quite home, which makes it a two-handed matter to fill the pen. Consequently it is generally preferable to cut the quill off and use an ordinary pen for filling the drawing pens with. It is advisable to keep the bottle closed as much as possible, as the modern ink dries very quickly, and soon thickens if exposed to the air.

The drawing pens should not be filled very full, as this usually results in blots, which takes longer to remove than it does to refill the pen; likewise, a penful should not be used up to the bitter end, as this will spoil the quality of the line.

If the pen is to be laid aside for a few minutes, the ink should be first removed by drawing a piece of cloth or folded blotting paper between the nibs, and if it is a hinged pen, it should be opened occasionally and given a thorough cleaning. Ultimately the nibs of a drawing pen become worn at one side, as the pen is always used in the same direction, and it begins to give a line of shaky quality. This can be put right by very carefully sharpening the pen on an oil stone, rubbing down each nib separately from the outside first, and then bringing them together and carefully rubbing the points together —and then testing with ink and trying again until the desired line is obtained without cutting the paper; but perhaps it is safer to send it to an instrument maker to be "set."

Now that needle points are so generally used and so easily replaced, the only instrument that needs looking after in this respect is the divider, which is usually supplied without needle points; and as this is probably used more than any other, it is well to sharpen the points occasionally, as visible holes in a drawing are unsightly and take the ink badly when that stage of the work is arrived at.

CHAPTER IV

ORNAMENTAL LETTERING

THERE are few more fascinating parts of a draughtsman's business than that of lettering up his drawings, or designing the lettering to be placed upon the inscriptions which are frequently used upon buildings. The first points to arise for consideration in this regard are suitability of style to the subject to be illustrated, the material in or upon which the lettering is to be done, and the tools to be employed, together, in the case of the work in a busy office, with rapidity of execution, and at all times absolute legibility. Often these various requirements conflict one with another, while at other times some are more prominent than are others, and some are occasionally absent. A good draughtsman will instinctively select the best style for the work immediately in hand, and will avoid the common faults of complexity, and of making his lettering to so small a scale that it is difficult to read.

Lettering has a history of its own, but for modern purposes it is unnecessary to go back further than the Roman. The ancient Assyrian arrow-head style of writing, the Egyptian hieroglyphics, and even the Greek and many more modern alphabets are useless in modern English practice, or are required only for very exceptional inscriptions.

The Roman style is that with which we are most familiar on the printed page, modern printers' type being a modification of it, with but little alteration. In two of its forms it is exceedingly useful to the draughtsman. Block lettering, whether upright or sloped, such as A B C or *D E F*, is amongst the clearest lettering which can be placed upon a drawing, and can be read even if it be exceedingly small. It is therefore most useful for drawings which are to be reproduced by photography to a smaller scale, as it remains legible when almost microscopic in size. The strokes, it will be noticed, are of the same thickness throughout, but the upright description is difficult to draw, taking a long time and needing great care. It is perhaps the best lettering of all for a student to start upon, as it trains him to exactitude more than any other. At the same time it is so slow that there are very few offices in which the time can be spared for its execution, and unless it be very well done indeed it looks bad, or at least commonplace. The sloped form is not quite so legible, but it can be much more rapidly written and need not be done with such extreme care, while its appearance is generally superior to that of upright block lettering. A judicious combination of the two will often produce satisfactory results particularly upon drawings which are of a practical rather than an artistic character.

The other form of Roman lettering which is in frequent use is that known as "*Italics*," as represented by the letters in which the word "*Italics*" is printed here. This is a form in common use amongst printers for purposes of emphasis, but it needs slightly altering if it is employed upon plans—as it frequently is, particularly by engineers. It is then made in small, or as they are called "lower case" letters, more like copper-plate handwriting, the letters being joined to one another, and some of them, such as "g," being of the handwriting character. Lettering of this description can be made legible, and written with extreme rapidity by anyone who is accustomed to it, while with the addition of a little artistic skill it may become pleasing. It has, however, been much more used upon mechanical than upon architectural work.

These are the forms which perhaps a student had best apply himself to at the outset, mastering and becoming perfect in them before he goes forward to anything more. It is upon them that he must obtain control over his pen, and learn to slope correctly. Before starting he should rule on his paper light pencil lines such as those in a copybook, indicating not only the upper and lower edges of the small letters, but also the terminations and the heads and tails of the extended letters, and the tops of the capitals. The longer extended letters are generally carried up to the same height as the capitals, and these are about 50 per cent. longer than the small letters and sometimes a trifle more. The small letter "t," however, only extends half as far above the ordinary line as any of the other extended letters. Besides ruling these guiding lines it is also advisable to rule a number of parallel pencil lines somewhat close together, but not necessarily equidistant, parallel to the slope. In other words, upright lettering should be ruled with a number of vertical lines, while slope lettering should have sloped lines inclined at an angle of about 70 degrees with the horizontal. These are only guide lines, and should be put in softly. A beginner will then pencil in everything that he has to write with extreme care, finishing the pencil work as if it were to be in ink; but as he gains control he will gradually cease using these pencil outlines, and will merely indicate in pencil where his letters ought to come so as to be sure to occupy only the correct spaces afterwards with his words. It is always well, however, to write every word in full, however roughly it be done, in pencil, and to carefully read it through

afterwards so as to detect any accidental mistakes in spelling, which are much more likely to occur in slow lettering of this description than in ordinary rapid handwriting, the omission of letters being a very common mistake.

There is a great temptation when employing block lettering, whether upright or slope, to use the drawing pen for straight lines, but if freedom is ever to be obtained and a good effect produced the hand only should be employed. Inking-in is generally done with a steel pen. For block lettering a coarse rather than a fine point should be used, according to the taste of the draughtsman, but if a sufficiently broad point is selected to accomplish the straight lines in single strokes it is so much the better. Many draughtsmen, however, prefer to use a somewhat fine pen, drawing the outline first and afterwards filling it in, and for a beginner this is undoubtedly the better plan, as he is enabled to correct any little irregularities on the fine outline. The curved letters will probably give most trouble, particularly "S" and "O," and difficulty will be experienced in keeping the lines of equal thickness round the curves.

Some workers of experience prefer a quill, but this is only to be recommended to those who know how to cut their own. It is not a difficult thing to do, but needs a little practice. Cut quills, as bought, are not generally of much value for the purpose until they have been recut, the slit being too long and the pen consequently too lissome. The slit is the first thing to attend to after the pen has been roughly shaped, and this should not be carried too far, an exceedingly sharp penknife being used to start it. The two nibs are then cut down towards it on either side symmetrically, and brought to a point exactly on the slit. The point can then be laid on the edge of a drawing board and cut off, either square or preferably at a slight angle, with a single sharp stroke of the knife. The slit need not, after the pen is finished, be more than about $\frac{1}{16}$ of an inch in length, and any necessary breadth of line can be obtained according to the way in which the nibs are cut.

Italic lettering may be ruled for in the same way as block lettering. It should be inked in with a somewhat fine steel pen. It is a mistake, however, to make the up-strokes too fine, as this results in the lettering being difficult to read. It is better to use a pen such as Mitchell's "G" than the mapping pen or Mitchell's "F," which are favourites with the engineer, except for very small work where one or other of these is essential; and the down-stroke should not be very greatly thicker than the up-stroke, though sufficiently so for emphasis.

In all forms of capital lettering, based upon the Roman, which has the down-strokes thick and the up-strokes thin, attention is necessary to ensure thickening the right strokes. Beginners will even make the mistake of thickening the vertical strokes of the letter "N" instead of the sloped stroke, while the wrong sloped stroke of "Y" is frequently thickened, and even experienced draughtsmen have been known to thicken the down-stroke of "S" in two blobs instead of a single clear stroke.

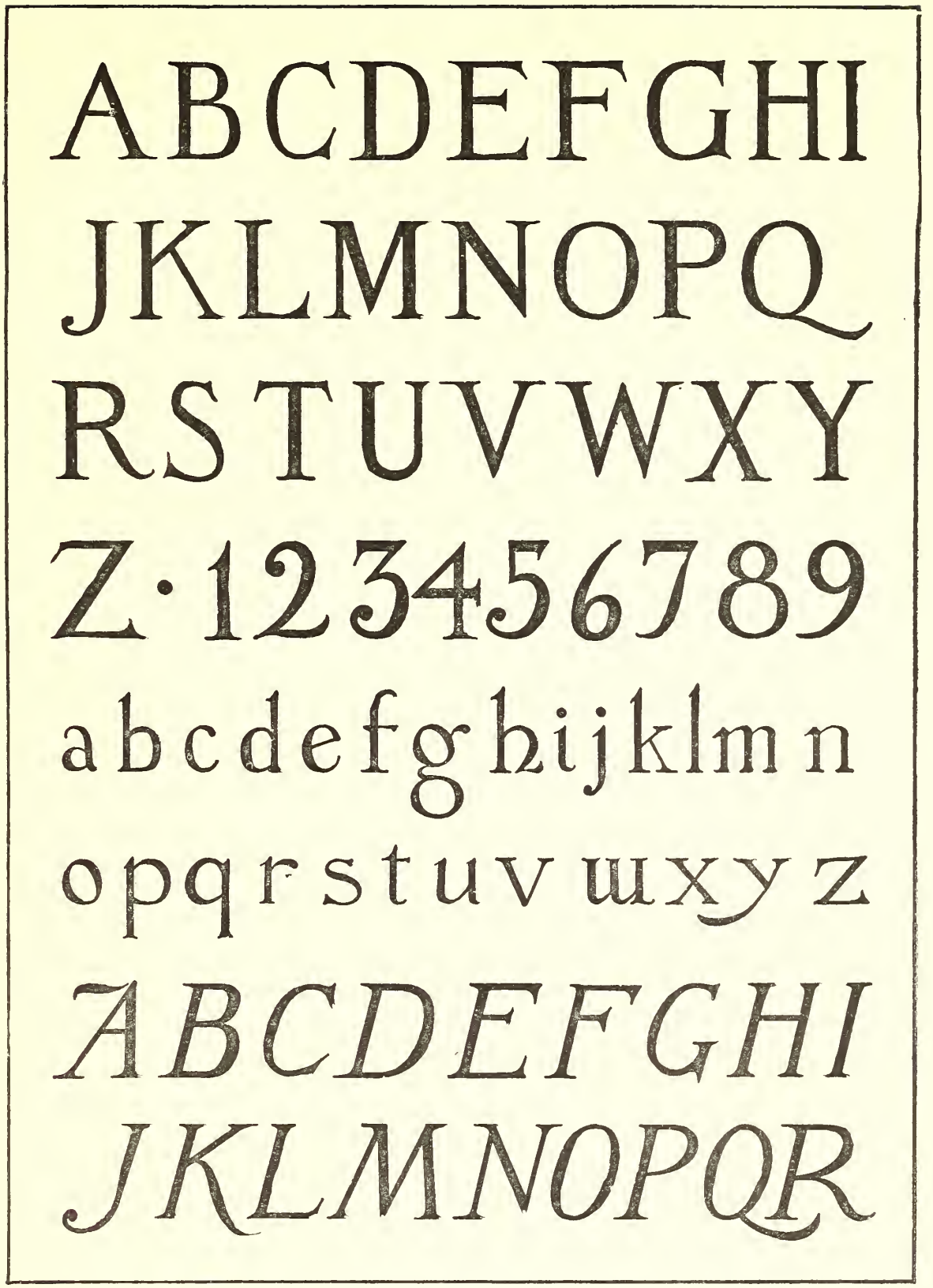
Renaissance lettering, such as that of which a sheet is given by way of illustration, is based very closely upon the Roman, and is capable of considerable variation. The alphabet of capital letters (illustration opposite) is very nearly that used upon the tomb of the Emperor Henry VII. in the Duomo at Pisa, the principal differences lying in slightly different curvatures of the little ticks at the letter terminals, known as "Serifs." It is a strong alphabet, very easy to read, the up-strokes not being too fine, but it takes a certain amount of time to write. The numerals are particularly pleasing, and can be made to combine well.

It may here be remarked that letters may often need slightly varying in order that they may combine properly with one another. As an example of this may be taken the letters "g" and "y" in the small alphabet, which, if they were to follow one another, would have to be somewhat altered, else the tail of the "y" would penetrate that of the "g." Small letters of the Roman or Renaissance form are rarely used except in print, owing partly to their being more difficult to draw than the large letters, and also to their being less easily deciphered. Upon drawings and inscriptions, and in fact for most purposes for which letters are used except on the printed page, different sizes of capitals are employed in preference to using the lower case letters. On this sheet it will be noticed that the Italic alphabet follows very closely upon the upright, being merely a sloped modification of it with the necessary alteration of such letters as "A" and "K" to make them properly fill their spaces and have a pleasing appearance.

The title to the page has been deliberately made of open lettering of a slightly different form, perhaps somewhat stiffer in character, use here being made of three different sizes of capitals. It is often very useful to employ open lettering of this class, as it can be made large enough to be easily deciphered without being so heavy as to draw attention away from the drawing which it describes. It needs to be carefully drawn, as there is not the opportunity of correcting a mistake such as exists when the outlines are filled with ink.

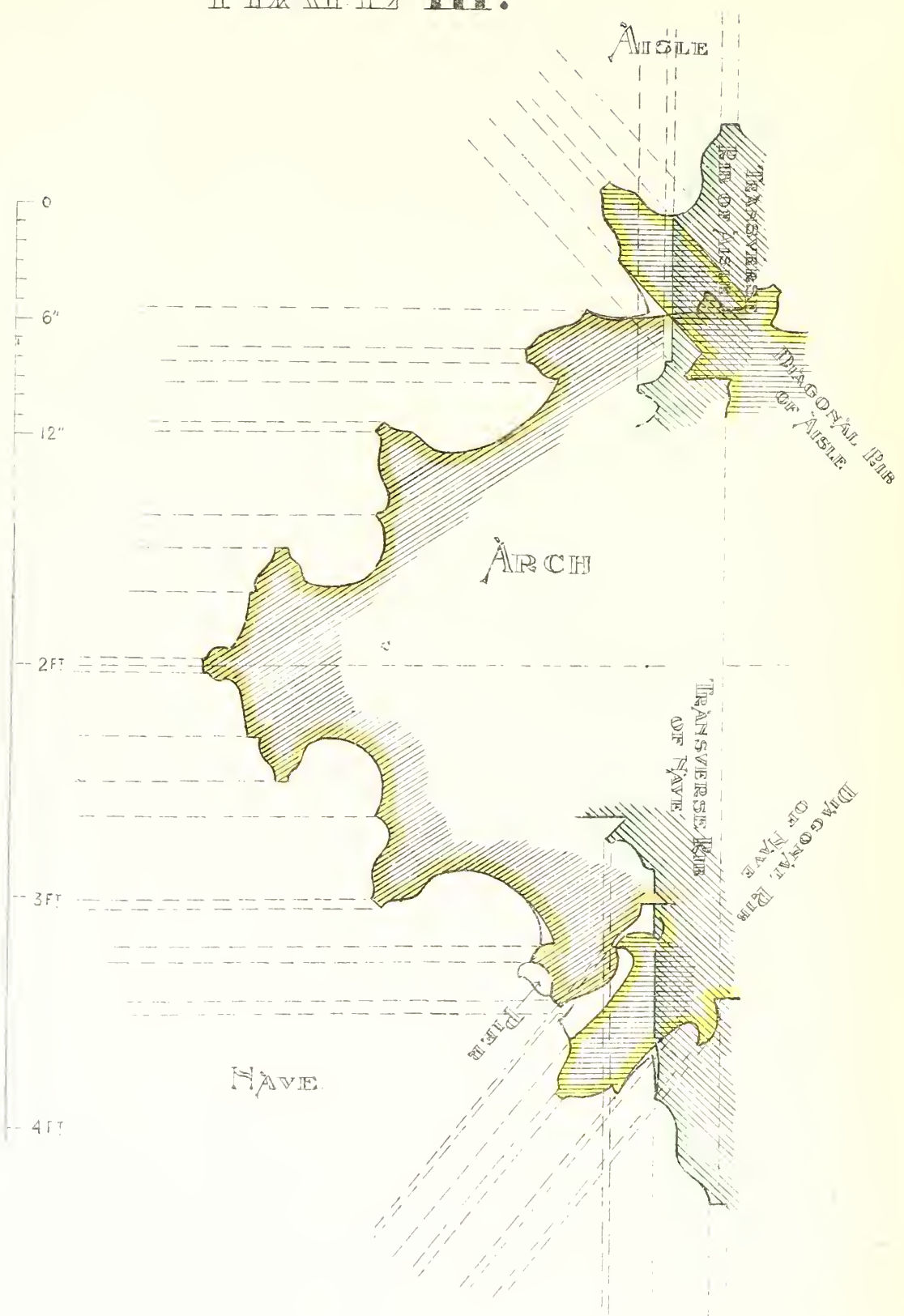
Throughout the whole of this sheet considerable use has been made of the T- and set-square, while the curves have been put in with a steel pen.

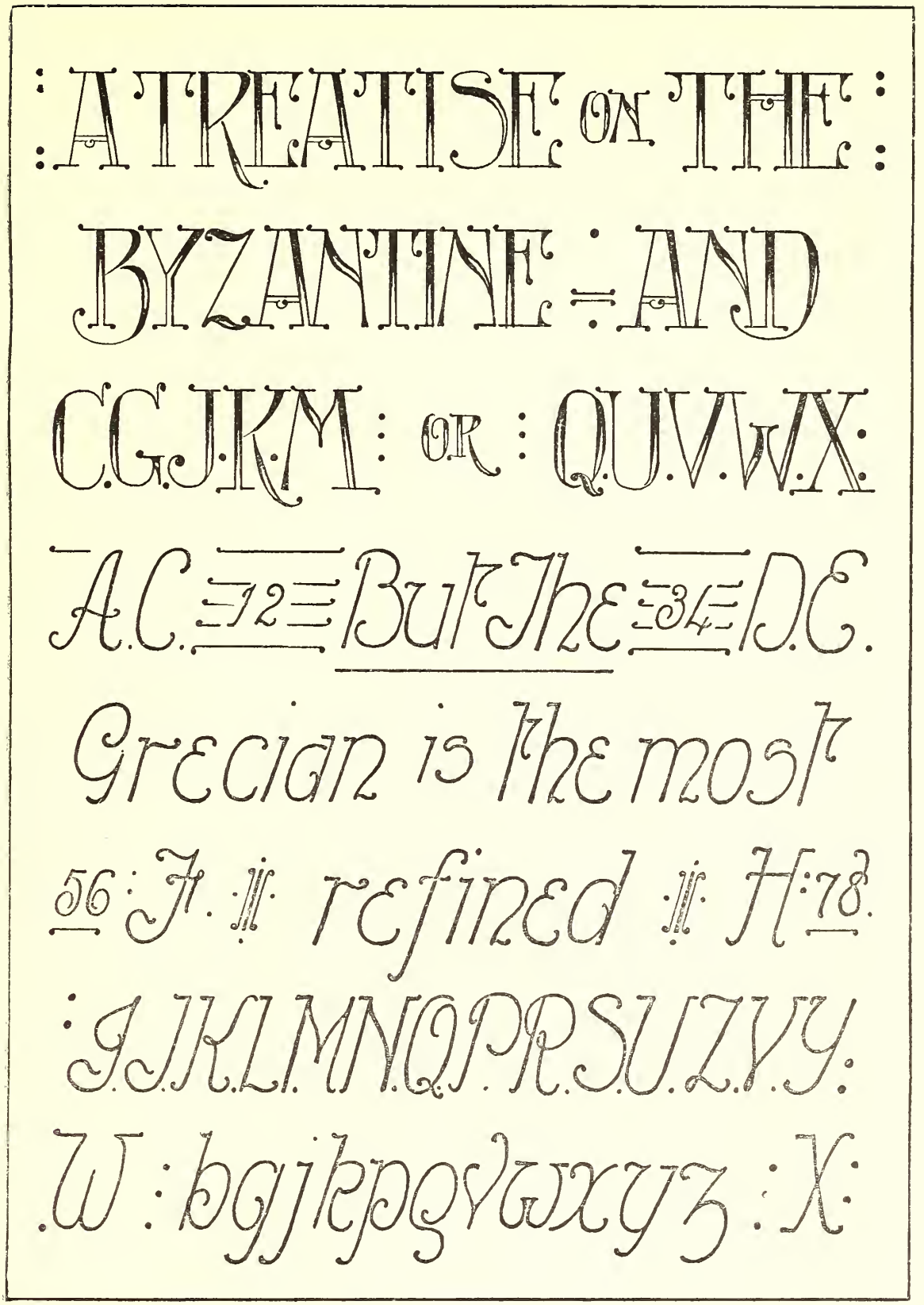
The sheet of Gothic Lettering has been differently treated, having been almost entirely done with the quill and freehand. It will be noticed that the forms of the letters are essentially different from those based upon Roman characters. They have been adapted from such as were usual upon English manuscripts of the thirteenth and fourteenth centuries, the German



A SHEET OF RENAISSANCE LETTERING:

PLATE III.


Aisle
Transverse line of Aisle
Diagonal line of Aisle
0
6"
12"
Arch
2Ft
Transverse line of Nave
Diagonal line of Nave
3Ft
Pier
Nave
4Ft



A SHEET OF MODERN LETTERING

alphabet of capitals not being given except in the title at the bottom, as it is much less applicable to present-day work. These Gothic capitals are shown in outline only, but are capable of being highly finished either by blacking in or by the introduction of colour and gold, while few alphabets look better in carved woodwork. For cutting in stone, however, they are by no means so useful as Roman letters, whether of the ordinary or the block form, as they consist almost entirely of freehand curves, which, although easy to cut in wood, are difficult to incise in stone. The quill was used as being the tool employed in the Middle Ages, and giving best the freedom of line which such a system of lettering seems to demand, with a certain amount of variation in its thickness, precise enough for its purpose and yet devoid of hardness. It needs to be used almost more like a brush than a pen, as pen use is now understood by those who are accustomed to metal nibs, the strokes being put in rapidly and with a flowing hand.

The small alphabet only approximates to that which it is best to employ with the capital alphabet above it, for it has been designed so as to be drawn almost entirely with the ruling pen, using the T-square and the 45° set-square only except for a few curves on the letters "e, g, h, s, y, and z." The necessary ruling for this alphabet is shown by the dotted lines at its commencement, to which another line might be added to denote the extremity of the tails of "f, g, j, p, q, y, and z." Had it been drawn freehand the alphabet might have been a good deal improved, and the direction in which this improvement might take place is suggested by the title at the bottom of the sheet, which, however, is again to a considerable extent drawn with the ruling pen.

Gothic letters are more adaptable to ornamental work than any others where the ornament is at all of the missal type, and is particularly useful for colour work, and for illuminating and engrossing.

Two variations are shown in the portions of sentences, one in outline and the other filled in, the latter having the small letters based more upon the Roman than upon the Gothic, although the harmony between them and the capitals is perfectly preserved.

Gothic capitals are particularly valuable for ornamental initials or versals—the *initial* being the first letter of a whole book or chapter, and the *versal* being the first letter of a paragraph. These need decorating in accordance with Gothic traditions, but there is no need to restrict oneself to precisely the forms of Gothic stone carving Working upon a plane surface and in colour the circumstances are different, and the materials used must be kept in mind. They also combine well to form monograms, of which an example is shown, at the bottom of the sheet, in the Imperial monogram E.R.I., the letters being enriched with tracery and diaper, and filled with thirteenth century Gothic ornament. This may vary to any extent according to the draughtsman's skill.

If Gothic Lettering suits, woodwork, it is Renaissance lettering which can generally be employed best for metal-work, a small illustration of this being given in the date Ao. 1663, which is a Belgian example of strap iron.

Modern lettering varies very greatly, but the general tendency is towards rapidity of execution and a certain complexity which is often difficult to decipher. Throughout this book there will be a large number of different styles illustrated upon the various drawings which will appear, and from amongst these it will be possible to choose, while each draughtsman is always at liberty to design for himself. In the examples illustrated here a little trouble has been taken to show a good modern ornamental alphabet which cannot be said to be definitely either Roman or Gothic in type, but a combination of both. The main alphabet of capitals has been half blocked in, this being a common modern expedient which looks especially well in pencil, but perhaps this particular alphabet errs on the side of fidgetiness owing to the large use of dots. For rapid and at the same time decipherable work of good appearance it is difficult to have anything much better than the type which makes up the words "Grecian is the most," if this be used without flourishes. All the other letters of this type, both capitals and small letters, as well as the numerals, will be found upon the page in one place or other, but there is no hard and fast rule, and it is possible to design or combine at pleasure. As an example of simple combination the way in which the three "n's" in the words "Byzantine and" are treated may very well be noticed. The title at the bottom of the page has again been employed to suggest another style of lettering, which, however, in unskilled hands may become exceedingly ugly. It is known as the Hatchet Lettering.

If lettering has to be used for anything else than pen, ink, and paper the limitations and needs of the material must be carefully studied before an alphabet is selected and its letters designed or modified. Stencil work in particular needs to be very carefully thought out, that the stencils may be cut so as not to be too fragile in any particular spot, and yet the letters when produced be without blemish. As is said in an important book on Alphabets, "The stencil letter should be clear cut, and somewhat blocked in, its curves having more the nature of an engraving than a painting about it; and ties, if rarely used, should either be pliable or form integral portions of some slight ornamentation."

Incised letters, such as those in stonework, are again different from carved letters, such as can be frequently used in oak and other hard woods, the grain of which will sometimes necessitate modification quite apart from any design prepared before the carver gets to work. Lacework, tapestry, and

engraving on brass or copper all require different treatment.

Perhaps in modern work it is the placing of letters which is more often in fault than their form, there being many good modern alphabets, while a very large number of draughtsmen are capable of executing beautiful lettering. It is difficult to lay down definite rules, however, for the arrangement of the lettering on a drawing or upon such a specimen of the art as a title page. There is much in the selection of the letters and of their relative size, and in the choosing or modification of them to enable them to combine well.

If a number of lines of lettering have all to be of equal length it is sometimes difficult to arrange the spaces between the letters and between the words so as to accomplish this without unduly crowding one line or spreading out another. Where this result has to be achieved it is imperative to carefully do the work first in pencil, as it may need to be rewritten two or three times before a satisfactory result is obtained without resort to the separation of a word into syllables, or at any rate to its being split into two parts which do not divide well. To take a well-known example, the word "manslaughter" might very well by a careless draughtsman be divided into "mans" - "laughter." To take another example, in which there is no ludicrous result by wrong placing of the hyphen, the word "without" may be selected. It obviously divides properly into "with" and "out," but if there were not quite room for the "h" in the first line without redrawing the letters a little more closely, there are many lazy draughtsman who would separate it into "wit" and "hout."

Enrichments and flourishes should be very sparingly used upon lettering, whose prime function is to describe a drawing rather than to decorate it. In much modern work there is an unfortunate tendency to over-elaboration, and, as on the specimen Modern sheet, to employ strokes and dots to such an extent as to fidget. A few emphasising lines or rows of dots, such as appear upon the Gothic sheet, are occasionally useful, particularly when applied to the headings of "show" drawings, but upon working and detail drawings the less ornament that is attempted the better; and, in fact, upon large scale details, nothing is better than very large plain lettering, done straight away with the brush, a good large sable being used—such a tool as it is impossible to "niggle" with.

Well-selected, well-drawn, and well-placed lettering is an ornament to any drawing; and while the placing is largely a matter of taste, it should conform to the rules of balance and symmetry which are applicable to all artistic work. Attention may in this respect be drawn to the sheet of Gothic Lettering, in which the comparatively light work above is in appearance carried by the large monogram below, while the ironwork date is introduced to fill up a gap and balance the two sides without exact conformity.[1]

[1] Many exceedingly beautiful and useful alphabets are to be found in the book by Mr. A. A. Turbayne, entitled *Alphabets and Numerals*, which is published by Messrs. T. C. and E. C. Jack, while the same author has produced a handsome series of volumes on *Monograms and Cyphers*, which includes almost all combinations of two and three letters. These are perhaps the greatest books on the subject which have yet appeared, and reference to them might be made by any who wish to carry the matter further.

ABCDEFGHIJK

LMNOPQRSTUV

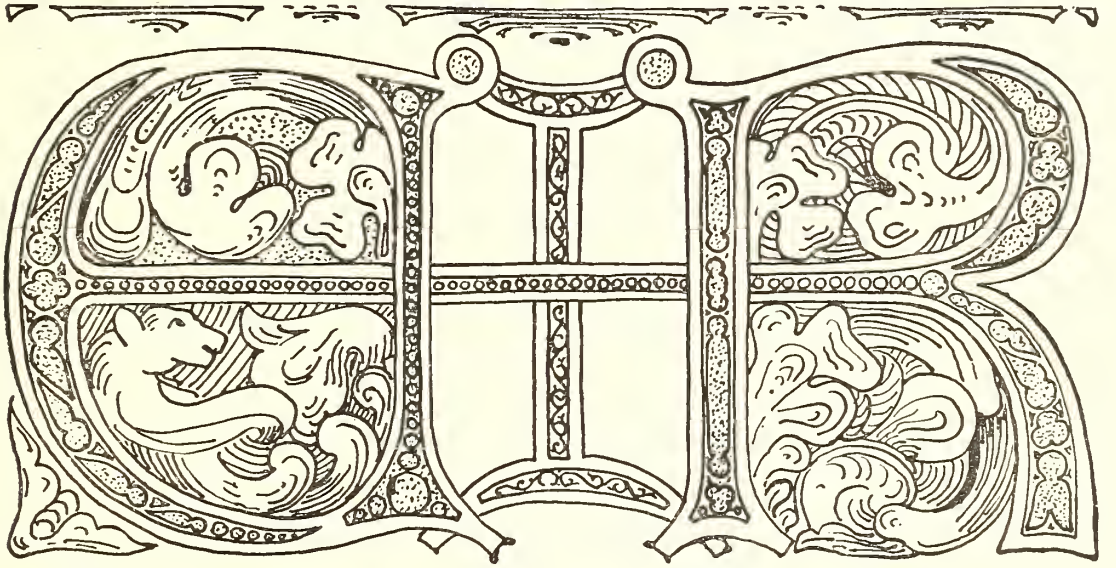
WXYZ1234567890

abcdefghijklmnopqrst

A. uvwxyz. 1663

Tell me, where is

Plan, Elevation, or



A Sheet of Gothic Lettering

CHAPTER V

SURVEYING EXISTING BUILDINGS

In all cases where alterations to existing buildings are required it is necessary to commence operations by making accurate plans of them, unless such exist and are accessible. To the uninitiated this looks to be an easy thing to do, and so it is if the building is set out on regular lines ; but this can never be assumed to be the case. The only safe assumption, in fact, is that there are imperceptible irregularities which can only be discovered by measuring and checking everything.

A plan is generally measured room by room in regular sequence, perferably starting with a central hall, if such a thing exists, out of which several rooms open, and, as it were, building up the plan round it. External measurements are generally taken after the interior has been finished—while sections follow plans, and elevations follow sections ; but many circumstances may occur to modify this sequence, such as the temporary occupation of a room, or the fact that fine weather, with the possibility of rain to follow, may suggest the advisability of doing the external work first.

As each room is entered a sketch plan is made of it in a large sketch book, using pencil and set-square, and it is advisable for this to be at least approximately correct to scale, else difficulty may be experienced in making the various pieces fit together, before the whole plan is finished. For this purpose squared or "sectional" paper is useful, and a scale of 8 feet to an inch is about as small as can well be used even by a draughtsman who writes a small hand and uses small, neat figures.

When surveying large buildings, a key plan to a very small scale has to be got out, with various portions lettered A, B, C, and so on ; and these portions are surveyed as if they were separate buildings, with a few connecting dimensions, each portion being sufficiently small to be sketched, to the scale adopted, on a sheet of the sketch book in use. In such cases the points of connection must be carefully noted and similarly numbered or lettered, preferably in colour, on each sheet of sketches.

To enable each room to be sketched, its leading dimensions are first taken, as shown in Fig. 24, round all four sides of the room, with a tape measure. It will be noticed that in this case neither the sides nor the ends are exactly alike, showing that the angles are not quite right angles, so that diagonals must also be measured (one is 16 ft. 8 in. and the other 16 ft. 6 in.) before the plan can be plotted with accuracy ; but even if the opposite sides had appeared to be equal, diagonals should still have been taken, for the whole might have been slewed into a rhomboidal form without its being perceptible to the eye. It is difficult to exaggerate the

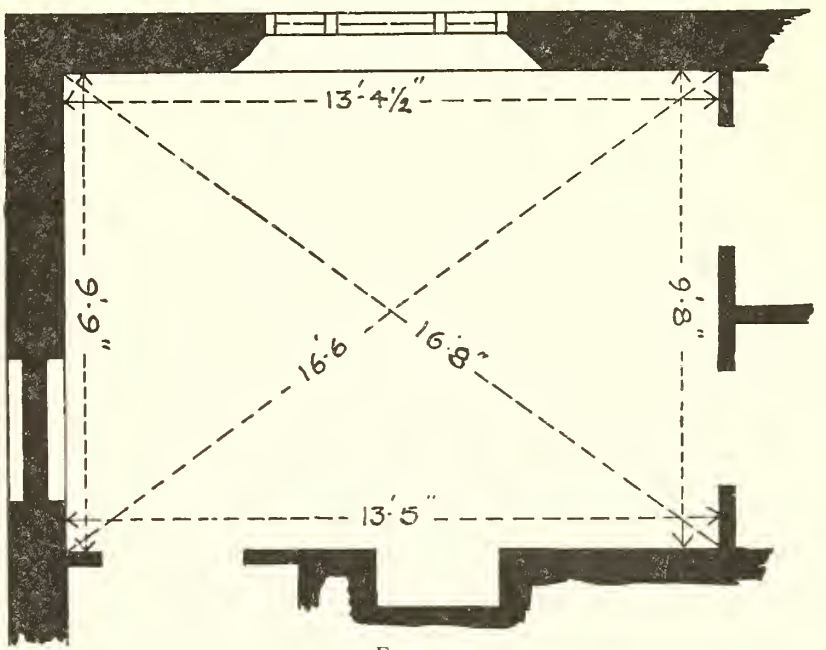


Fig. 24.

necessity for taking diagonals whenever the opportunity for doing so presents itself, while important points should be connected by still further lines, unnecessary in themselves, to serve as checks upon the work.

The tape used should be tested now and then against a steel tape kept for the purpose, it being liable to stretch ; but the steel tape itself is not flexible enough for employment in a room, as it cannot be got into a corner. An assistant holds the ring at the end of the tape at one extremity of the side or diagonal to be measured, while the person who is responsible for the survey, and who makes the entries in the sketch book, reads off the dimensions at the other end ; and, if the assistant be new to the work, it must be impressed upon him that measurements start from the outer end of the ring, and not from the junction of ring and tape. If two assistants take the measurements while the surveyor enters them on his sketch the work is

greatly facilitated; but the surveyor must then always repeat aloud every dimension as it is dictated to him, as a precaution against mis-entry.

After the main dimensions and diagonals have been taken, and the main plan sketched in, the details are measured, starting at one corner and working round. Thus the upper end of the room in Fig. 24, when fully detailed, appears as in Fig. 25. These measurements are taken either with a 5-foot rod or a 2-foot rule, as may be most convenient, and very rarely with the less accurate tape.

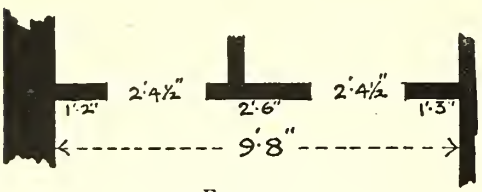


Fig. 25.

When a string of detailed dimensions has been taken, they should be added up to ascertain if the total agrees with the general over-all dimension. In this instance 1 ft. 2 in. + 2 ft. 4½ in. + 2 ft. 6 in. + 2 ft. 4½ in. + 1 ft. 3 in. = 9 ft. 8 in., and consequently all measurements are correct, it being most unlikely that a mistake of similar amount should have been made both in the detailed and the general dimensions.

It sometimes happens that, owing to temporary obstructions, direct diagonals cannot be obtained, while in other cases they are not procurable, the room itself being of irregular shape. In such instances the best has to be done that circumstances will allow, several cross measurements, for example, being taken from the centre of a newel post in a staircase hall, or from the projecting angle of a chimney breast,—or even from a chalk line drawn on a wall. Technically all these cross measurements are known as "diagonals," and it is an accepted axiom that it is impossible to take too many of them if accuracy is to be ensured.

The thicknesses of walls can generally be obtained at door or window openings. These are measured *gross*, including plaster, contrary to the general practice in preparing working drawings for new work, for the inside measurements of the rooms have, as may be noticed, already been taken nett along the faces of the walls as they exist. The unwary may, however, be warned against taking measurements so low down as to involve the skirting boards also.

When a cross wall has no openings in it its thickness has to be ascertained indirectly, as shown in Fig. 26, where the sum of 2 ft. 4 in. and 3 ft. 2 in. is 5 ft. 6 in.,

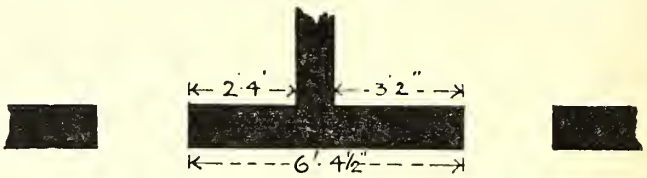


Fig. 26.

and the difference of 10½ in. between this and 6 ft. 4½ in. is obviously the thickness of the wall in question.

It was by the adoption of these methods only that the somewhat irregular little cottage was measured whose ground plan is shown as an example in Fig. 28 opposite, and almost anything can be done in the same way, by gradual extension of the process; though occasionally an irregular outline may have to be obtained by stretching the tape across an opening and taking ordinates to it as shown in Fig. 27,—or a chalk line drawn on the floor or ceiling may have to serve in place of the tape.

When a building consists of several storeys it is, as a rule, only necessary to measure the plan of the ground floor in its entirety. This can be plotted carefully on drawing paper, testing everything with the diagonals and remeasuring if any discrepancy appears. The drawing thus made may be treated as the basis upon which to found the measurements of other floors, all main walls, which obviously run through on to other floors, being traced as many times as there are storeys, including basements,—or if there are several storeys, one tracing may be made and several sun prints, with black or brown lines on white paper, made from it. These tracings (or sun prints) may be pinned on to small drawing boards and used for detailing the other floors on, the outline being now known to be correct, and any alterations in the thickness of the walls being figured before detailed measurements for the positions of door and window openings, partitions, stairs, etc., are taken. Of course, if windows occur exactly above one another on every floor, they also may be shown on the tracings, it being easy to figure

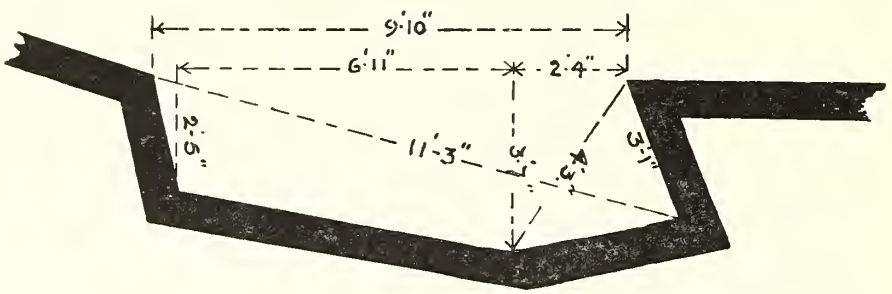
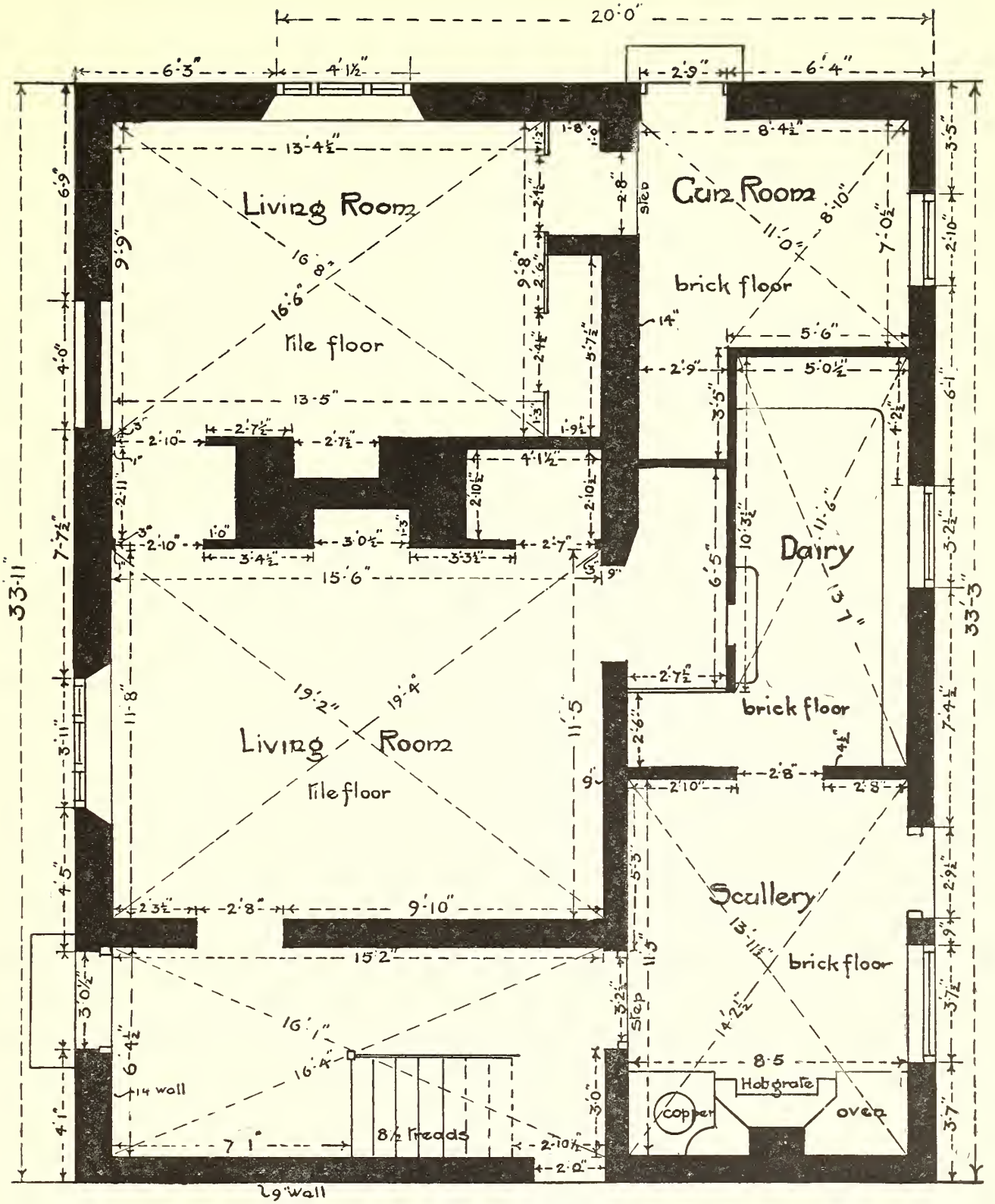


Fig. 27.



Survey plan of a Farm Cottage.

FIG. 28.

any small alterations either in size or position. Stairs should be shown and measured separately on each floor, and ought to be numbered as well as measured, and the number in each flight recorded.

Sections are measured in the same manner as plans, except that diagonals are rarely needed—only if the walls, when tested by a plumb-line, prove to be out of vertical, or if the floors are not level. The most common difficulties occur in ascertaining the thicknesses of floors (often to be measured at staircase well-holes) and the slopes of roofs. Fig. 29 illustrates the sketch section of the cottage whose ground plan is given in Fig. 28, and shows, better than any amount of description could do, how all that is necessary has been obtained with very few dimensions. As a rule sections are best measured through a staircase, and the number of stairs should be correctly shown and figured both on section and plan.

Elevations are similarly measured, the work being simplified by the positions of the main openings having already been located on the plans; but architectural features have necessarily to be recorded in general outline and detail. The positions of continuous horizontal lines are usually ascertained first, and heights are measured from these, either upwards with the 5-foot rod or downwards by means of a tape having a weight suspended from its ring. Several points in a curve, for example, such as O, P, and Q (see Fig. 30), can in this way be very exactly determined by means of horizontal measurements x, y, and z, and corresponding vertical measurements a, b, and c, downwards from a horizontal string course or moulding.

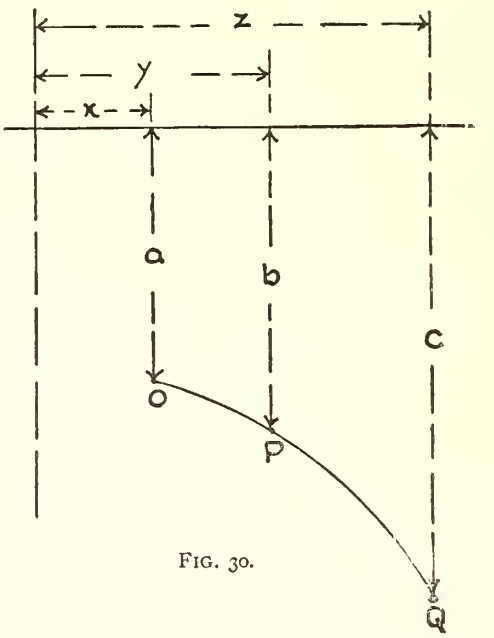


Fig. 30.

Fig. 31 shows a window in simple plate tracing with all essential dimensions figured and the rest sketched, the purpose for which it was needed not having demanded an absolutely correct drawing.

Mouldings are almost always measured on a system of ordinates, the contours being sketched, their outlines being ascertained more accurately by the

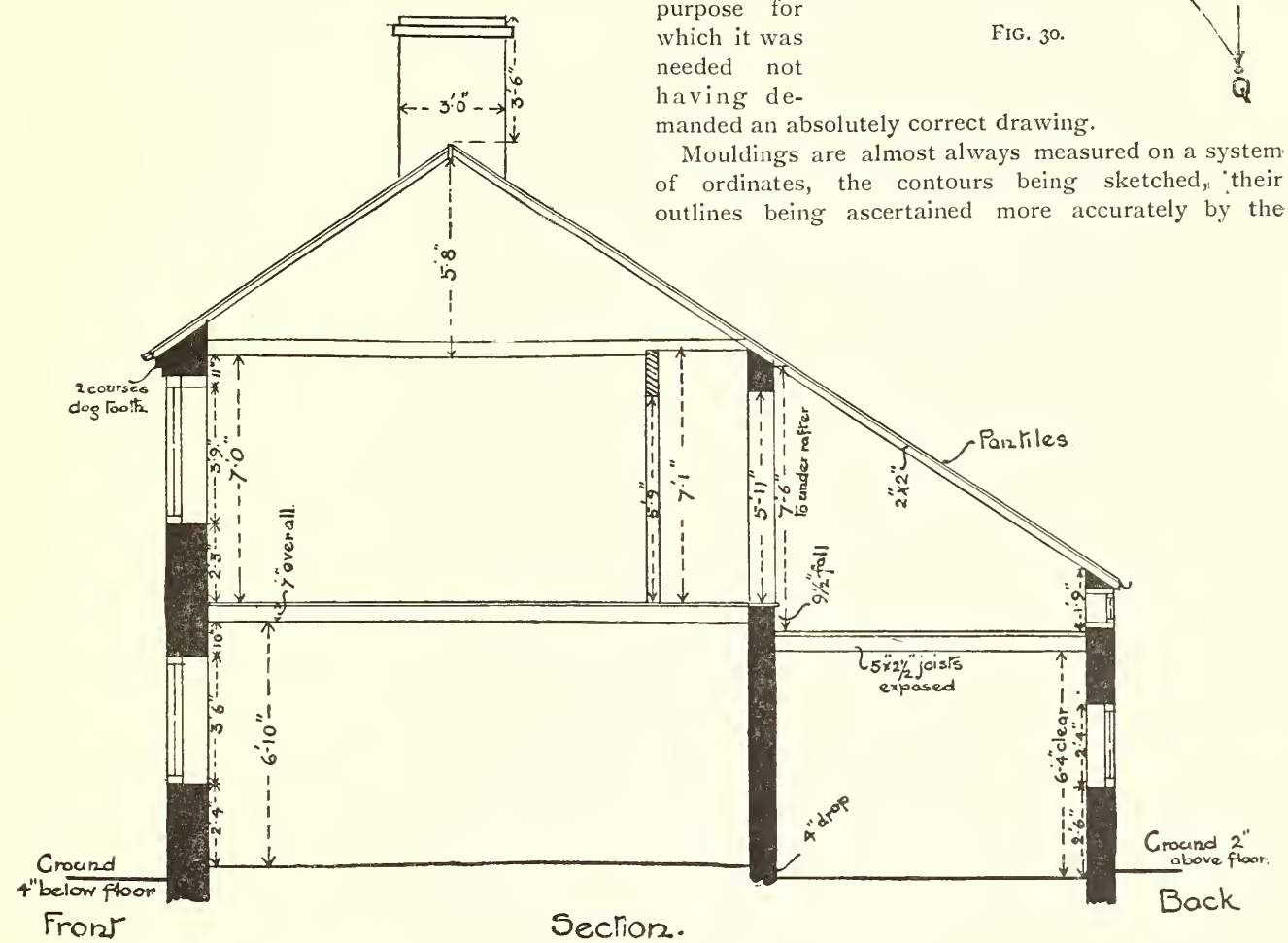


Fig. 29.

sense of touch than in any other way if an actual section is not visible, the fingers being passed gently into the hollows and along the contour. It is in this way that the actual contours shown both in Fig. 32 (which is a section of the arch moulding of the door

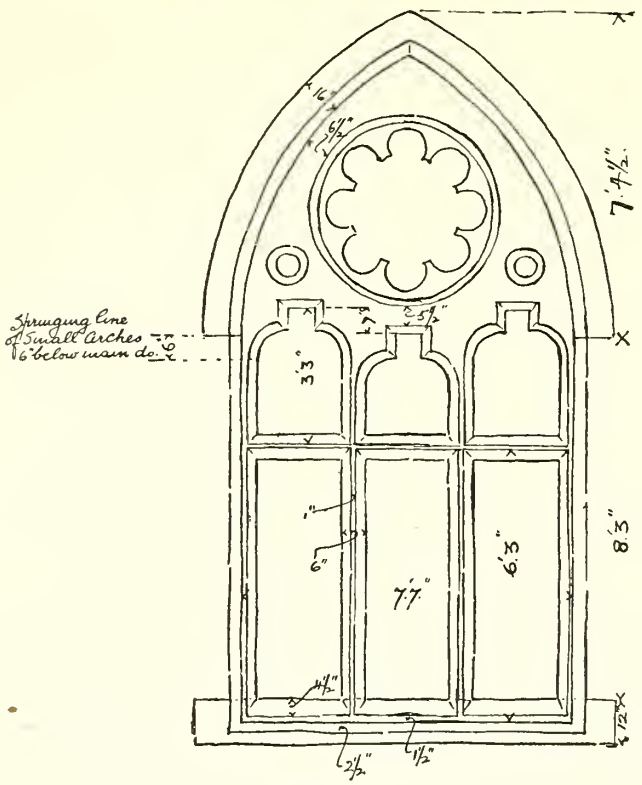


Fig. 31.

to the Hôtel du Duc de Rouen at St. Brieuc) and in Plate III. were obtained. The measurements for Fig. 32 were taken as shown, but Plate III. was drawn to scale on the spot, the measurements being taken as co-ordinates along the dotted lines. In order to show clearly how the vaulting ribs sprang by interpenetration from the pier in this very interesting and characteristic piece of French "Flamboyant" work of the sixteenth century, it has been necessary to employ colour, the principal arch and pier below being shown in sepia, the transverse ribs of the vaulting in blue, and the diagonal ribs in yellow.

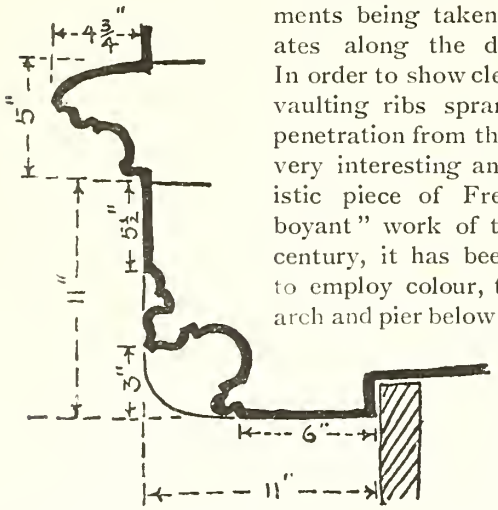


Fig. 32.

The more ornamental details of a building are frequently sketched to a larger scale, either in front and side elevation or in perspective as shown in Fig. 33, their positions being described or indicated by reference letters; but whenever time permits it is much better to make elaborate elevational drawings to scale on the spot at once, as was done with the half bay of the Cloister of St. Maclou at Rouen, shown in Fig. 33A. There the intricate detail could scarcely have been accurately placed had each little bit been sketched separately; and it is doubtful whether in the end any time would have been saved, as the drawing was commenced and completed in the course of an afternoon. No set-square was used, but all lines were drawn with the aid of a small T-square working along the edge of a drawing block. The same procedure is followed in such a case as when rough sketches only are made on the spot, general

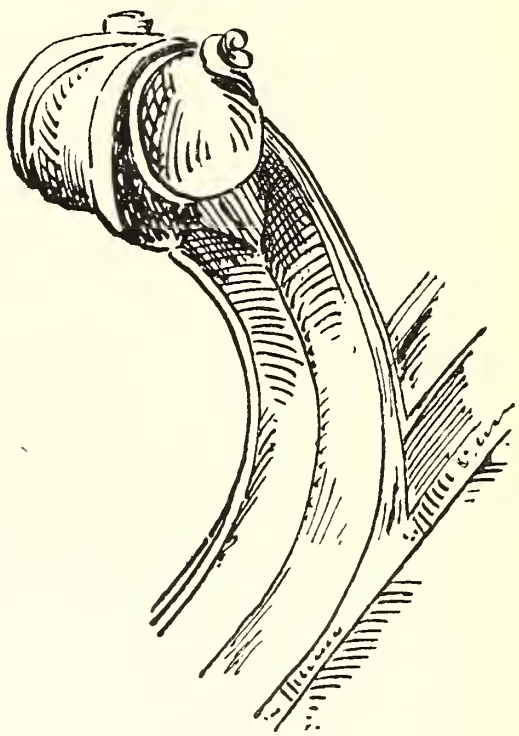


Fig. 33.

covering dimensions being taken first and the detail filled in afterwards gradually, starting with the major and finishing with the minor features, correctness being checked both by scale and by totalling the smaller dimensions to ascertain whether the total coincides with the covering measurement.

Measured drawings of this sort are not only essential preludes to the preparation of schemes for alterations, but their preparation has also an exceedingly high educational value if the examples be well chosen.

Finally, at the risk of repetition, it must be urged that it is far better to take too many dimensions than too few, that it is unsafe to make assumptions, and that every important point should be located by at least three dimensions concurring at that point.

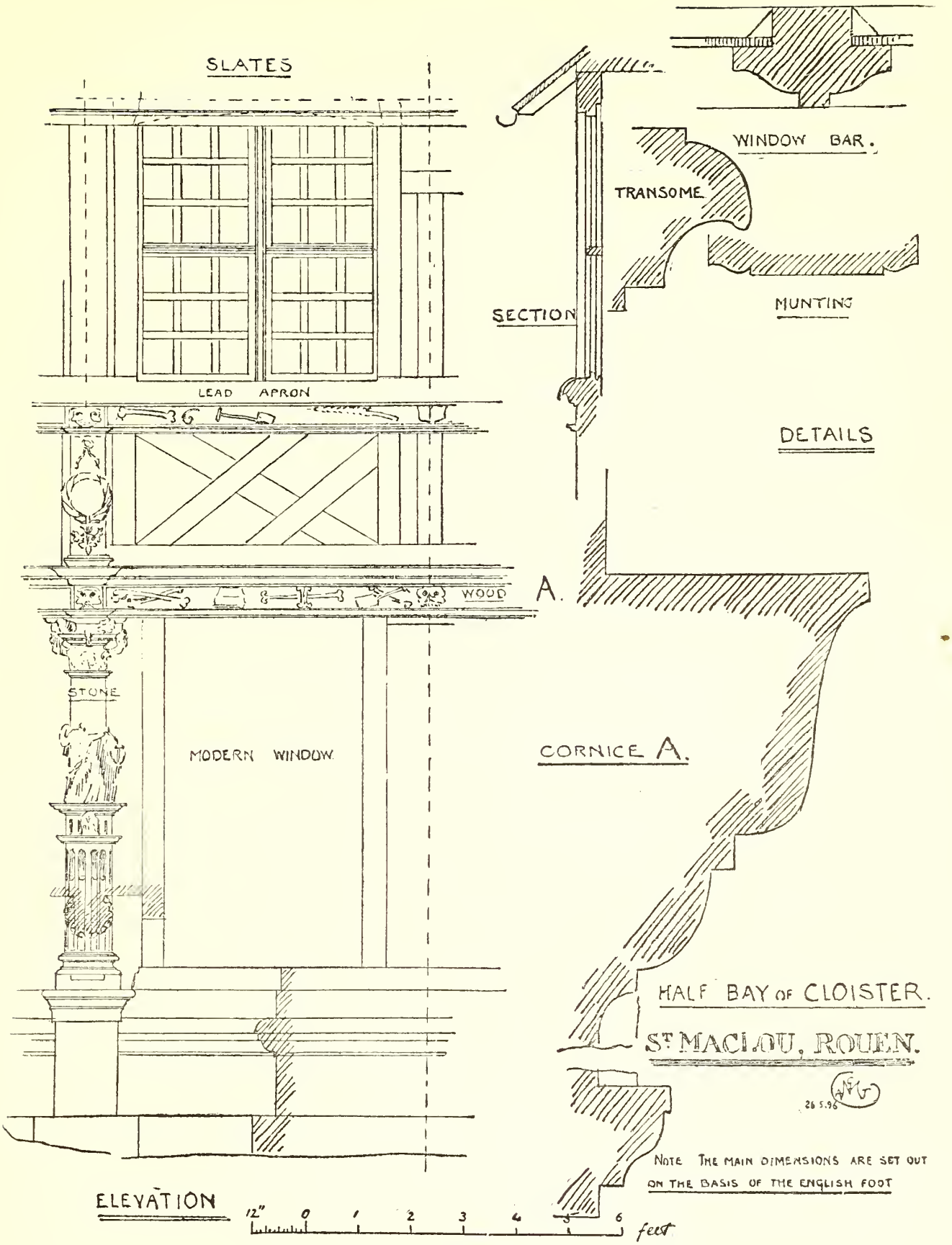

SLATES
LEAD APRON
WOOD
STONE
MODERN WINDOW
ELEVATION
SECTION
WINDOW BAR.
TRANSOME
MUNTING
DETAILS
A.
CORNICE A.
HALF BAY OF CLOISTER.
ST MACLOU, ROUEN.
26.5.98
NOTE THE MAIN DIMENSIONS ARE SET OUT ON THE BASIS OF THE ENGLISH FOOT
12" 0 1 2 3 4 5 6 feet

FIG. 33A.

CHAPTER VI

A MODEL SPECIFICATION

THE specification detailed in the following pages is given as a general indication of the basis upon which such work is carried out. It is for three cottages, and is merely a suggestive model, upon which other satisfactory specifications for small work might be founded; but it is quite open to modification, and may by some be thought to be too complete. It contains no single clause but might be differently worded with just as good results, and in no case should it be copied and applied to other buildings without full consideration of the meaning of every sentence.

The principle followed is the usual one of specifying each trade separately in a sequence which has become customary, introducing the whole with a few general clauses which either refer to all trades or which cannot be allocated to any.

Within each trade the materials are first described, in greater or less detail according to the requirements of the case, and then the workmanship, in regular sequence from bottom to top of the building, as nearly as possible in the order in which the work would be executed. Each item has a separate paragraph devoted to it, and every clause is worded as a distinct order, as to the meaning of which there can be no dispute. Marginal notes indicating the matters to which the clauses relate should be in red; and in large specifications the clauses are numbered and indexed with great care.

In the present instance the stipulations as to quality are not severe, for cottage work is naturally not so elaborate or of so high a class as most other that an architect specifies for. Ordinarily good and honest work is all that is required.

SPECIFICATION

SPECIFICATION OF WORKS to be done and the materials to be used in the execution of a row of three Labourers' Cottages at in the County of , according to plans prepared by and under the superintendence of

———————————*Architect.*

———————————[*Address here*]

[*Date here*]

PRELIMINARY

All materials and workmanship are to be of good quality, to the satisfaction of the architect, whose decision is final.

All work reasonably to be inferred from the drawings is to be executed whether specified or not.

The work consists mainly of clearing site, grubbing up all trees, erecting new buildings and laying various new pavings and drainage.

The contractor is to supply all materials, tools, tackle, scaffolding, implements, and cartage, and everything necessary for the proper carrying out and completion of the works to the full meaning and intent of this Specification and the Drawings.

Clean windows, sweep flues, wash floors and stairs, remove rubbish, and leave all clean and tidy on completion.

All trades are to wait upon and make good after all other trades as may be necessary.

EXCAVATOR

Trenches.—Excavate the ground to the depths and widths required for the various drains and foundations according to plans; deposit where directed or cart away; part fill in and ram to all footings and walls.

Surface Earth.—Remove the surface earth to an average depth of 6 in. over the whole site; wheel and deposit where directed or cart away.

Brick Rubbish.—Lay dry brick rubbish over the site between walls; level up and well ram to within 6 in. of finished surface to receive concrete.

Concrete.—Put concrete composed of six parts of hard clean material (flints, broken brick, or as otherwise approved), one part sand and one part of best blue lias lime, under walls, of the widths and depths shown.

Lay concrete 6 in. thick, composed of one of Portland cement to six of gravel or broken brick, under all floors; those of the scullery, coal place, larder, and w.c. to be floated with 1 in. of Portland cement and sand of the proportion of 1 to 3 trowelled to a smooth surface, and all others to be roughly levelled.

Drains.—Lay drains where shown on plans with 4-in. glazed stoneware socketed pipes, thoroughly burnt and free from all defects, jointed in cement and laid, with a fall of 1 in 40 ft., on and surrounded in 6-in. concrete composed of one part of Portland cement to six of gravel or broken bricks.

Provide all necessary bends, junctions, etc., and connect to sewer in road in accordance with local regulations.

Drain Test.—All drains to be tested with water to

the architect's satisfaction before the concrete is filled in.

Fresh Air Inlets.—Provide fresh air inlets of approved maker, fixed where shown on plan, and connected with 4-in. stoneware pipes jointed in cement to disconnecting chamber.

Gullies.—Provide gullies where shown to take discharges from sink wastes with galvanised grid with one 4-in. intake each for rain-water drains, and form coping in cement and sand in proportion of 1 to 3.

Rain-water Shoes.—Provide and fix rain-water shoes with galvanised grids at all down pipes, except that which discharges over gulley outside scullery (centre house).

Disconnecting Chamber.—Form cement concrete bed 6 in. deep below invert of channel pipes to disconnecting chamber, lay one course of bricks along each edge of main channel, and bench up with cement concrete so as to fall to top of this course of brick or to branch channels.

The bottom and sides of chamber are to be rendered in cement and sand in proportion of 1 to 3.

Provide and fix approved 4-in. brown intercepting sewer trap at outlet from chamber, the main half pipe through chamber to be 4 in. diameter 3 ft. long, and the branches to be 4 in. laid to cascade into main channel, and to be three-quarter round in section, and to proper bends to discharge in direction of flow of main channel.

The walls of chamber are to be in 9-in. stock brickwork in cement mortar (1 to 1), corbelled in to take the 2 ft. 7 in. by 1 ft. 10 in. galvanised cover, and to be fixed level with surface of back garden, and are to be rendered internally in cement mortar.

Bricklayer

Bricks.—The bricks for backing and internal walls are to be sound and well burnt yellow stock bricks; those for external facings to be picked stocks; and those for external facings of chimneys to be hand-made red facing bricks from an approved maker.

No four courses are to rise more than $1\frac{1}{4}$ in. in addition to bricks laid dry.

Mortar.—The mortar is to be composed of one part of good lias lime to three parts of sharp pit sand.

Walls.—Build all walls of the heights and thicknesses shown, the $4\frac{1}{2}$-in. walls in stretcher bond and all others in English bond, on two courses of footings laid on the concrete already specified, well bedded in mortar and finished as the work proceeds with a neat flat joint wherever exposed externally, and in scullery, coals, larder, and w.c. internally.

Sleeper Walls.—Build all necessary sleeper walls honeycombed for passage of air.

Damp-proof Course.—Lay Callender's patent asphalte damp-proof course round all walls below level of wood sleepers, and where this is less than 6 in. above the ground render externally in cement and sand (1 to 1) from one course below to three courses above level of damp course.

Arches.—Turn relieving arches over all openings in two $4\frac{1}{2}$-in. rings, save in $4\frac{1}{2}$-in. walls and where otherwise directed.

Turn arches over all fireplace openings on $2\frac{1}{2}$ by $\frac{5}{8}$ in. wrought-iron chimney bars with caulked ends, turned up and down.

Form flat lias lime concrete trimmer arches 6 in. thick under hearths of first floor, supported by $\frac{3}{4}$-in. boarding on fillets nailed to trimmer joists and made up to under side of hearths, and rendered in cement to a fine surface.

Flues.—Properly form and parge and core all flues, and build kitchen flues in right position for range.

Coppers.—Build copper casings in sculleries, and form flue from ditto to connect to kitchen chimney as directed with easy bends, and provide and fix an iron damper in scullery to copper flue. The pan for copper is to be of galvanised iron, and to hold ten gallons. The furnace door and grate to be of heavy quality.

Chimney Stack.—Build chimney stacks with sailing course as shown. The top four courses are to be in cement mortar with cement mortar weathering to projecting bands.

Chimney Pots.—Provide and set approved fireclay chimney pots, P.C.—each to all flues well flaunched in cement.

Airbrick.—Build in under floors No. 4 C.I. airbricks per cottage where directed. Build in two C.I. airbricks just above floor level in larders.

Sinks.—Provide and fix in sculleries No. 3 brown glazed stoneware sinks, 2 ft. 6 in. by 1 ft. 8 in., and build $4\frac{1}{2}$-in. dwarf walls to carry same.

Beam fill.—Beam fill between feet of rafters and ends of joists.

Set Stoves and Ranges.—Properly set all stoves and ranges, filling same in solid at back.

Bed Door and Window Frames.—Properly bed all door and window frames, lintels, and plates.

Gables and Cuttings.—Carry out all necessary cuttings and pointings to gables of roof and cuttings to skewbacks to arches.

Stone Steps.—Provide and fix rubbed York or Forest of Dean door landings and stone steps to front entrance and back doorway.

Tarred Base.—Put tarred base all round building as shown.

Stone Mantel.—Provide and fix 9 by 2 in. rubbed York or Forest of Dean stone mantel joint and shelf in each kitchen, properly cramped to wall.

Carpenter and Joiner

Timber.—All timber except where otherwise specified is to be sound Baltic fir well seasoned, entirely free

from large and loose knots and shakes ; cut die square, not to contain more than 25 per cent. of sapwood, and to be of the scantlings given when finished. Cut timber into scantling lengths immediately after signing contract.

Unwrought timbers when fixed are to hold the full dimensions specified.

All exposed faces are to be wrought, except where otherwise described.

No joints or rafters are to be placed more than 12 in. apart.

Supply all necessary backings, grounds, fillets, moulds, templates, heads, woodbricks, slips, finishings, and fixings, and perform all necessary grooving, rebating, jointing, framing, and all work requisite throughout.

Lintels.—Provide lintels of the full width of brickwork, and of the same depth in inches as the opening is wide in feet, to all door and window openings ; but no lintel is to be less than 3 in. in depth.

Provide three 9 by 3-in. lintels bolted together for windows in gable at back.

Joists.—The ground-floor joists are to be 5 by 2 in. on $4\frac{1}{2}$ by 3-in. sleepers laid on the sleeper walls ; first-floor joists 7 by 2 in. with trimmers and trimming joists 7 by $2\frac{1}{2}$ in., and the wall-plates $4\frac{1}{2}$ by 3 in.

Herring-bone Strutting.—Put one row of herring-bone strutting to first-floor joists wherever the span exceeds 6 ft.

Floor Boards.—Cover all wood floors with 7 by 1-in. wrought yellow boards rebated, tongued, and grooved, with glued and mitred margin to all hearths.

No Timber in Party Walls.—No timber is to be laid in the party walls dividing the cottages, but any wall-plates which would occur therein are to be carried on iron brackets cemented into the walls.

Roof Rafters.—Form roofs with 4 by $2\frac{1}{2}$-in. rafters not more than 12 in. apart on $4\frac{1}{2}$ by 3-in. wall-plates, halved and spiked at angles and heading joints.

Purlins and Struts.—The purlins to be 7 by 3 in., supported where practicable by 4 by 3-in. struts resting on top of partitions.

Ridge.—The ridge to be 7 by $1\frac{1}{2}$ in.

Ceiling Joists.—The ceiling joists are to be 4 in. by $2\frac{1}{2}$ ft., spiked to the feet of rafters and notched to all plates so as to act as ties. Fix 1-in. fascia and $\frac{3}{4}$-in. soffit boards to all eaves.

Trim for Gables.—Trim roof to form gables with 4 by $2\frac{1}{2}$-in. rafters and 4 by $2\frac{1}{2}$-in. collars, and 7 by $1\frac{1}{2}$-in. ridge.

Hip.—Form hip at end of roof as shown with 9 by $1\frac{1}{2}$-in. hip rafters.

Trim for Dormers.—Trim for clear opening 3 ft. 6 in. wide for dormers, form up side with 4 by 2-in. studs, 4 by 3-in. heads and sills, and 4 by 4-in. corner posts, and trim rafters to form roofs ; those at the back to be hipped.

Boarding.—Cover the whole of the roofs and sides of dormers with $\frac{3}{4}$-in. rough boarding, edges shot.

Barge Board.—The true purlin of main roof is to project 9 in. at each end, and false purlins to be built in where directed, the ends being covered with a 9 by 2-in. wrought barge board.

Tilting Fillet.—Put $1\frac{1}{2}$-in. tilting fillets at eaves of main roof, gables, and dormers.

Fascia.—Fix 1 by 7-in. wrought deal beaded fascia screwed to ends of rafters.

Stud Partitions.—Frame stud partitions with 4 by 4-in. sills and heads, posts, and lintels, and 4 by 2-in. studs placed not more than 12 in. apart, the whole to be mortised and tenoned together, and having two 4 by 2-in. nogging pieces as interties in height of storeys.

Penthouse.—Form penthouse over front and back doors where shown on elevations to detail, with 3 by 2-in. rafters, plates, tiles, and curved brackets, wrought on all sides.

Sills.—Unless otherwise specified, the sills to solid and cased frames are to be in English oak 11 by 3 in. sunk, weathered and throated, and built into brickwork $4\frac{1}{2}$ in. each end.

Window Frames.—Fill in each window opening on ground floor with wrought deal-cased frames, with 1 in. grooved and beaded outside lining, 1-in. inside linings with 1 by $\frac{5}{8}$-in. beading planted on, $1\frac{1}{4}$ in. twice rebated and grooved pulley style, with pocket piece for access to weights, and $\frac{3}{8}$-in. parting beads, 2 in. twice rebated and grooved head lining, blocked out, with $\frac{3}{8}$-in. porting bead planted on, and beading planted on inside, $\frac{1}{2}$-in. back linings, and $\frac{3}{8}$-in. parting slips, and 3 in. sunk, weathered and throated oak sill as mentioned above, grooved for water bar with a checked out bead 2 in. deep planted on for ventilation.

Sashes.—Fill in each frame with $1\frac{1}{2}$-in. moulded double hung deal sashes, with ovolo-moulded sash bars rebated for glass, splayed bottom and meeting rails, with two moulded horns to each sash. Hang sashes with strong hemp line over brass-faced axle pulleys and balance with C.I. weights, and provide with sash fastener, list price 1s. 6d. each, to the architect's approval.

Larder Window.—The larder windows to be $1\frac{1}{2}$-in. casements, opening inwards and hung with 2-in. W.I. butts to $4\frac{1}{2}$ by 3-in. solid rebated frame. Oak sill as above. Perforated zinc sheeting to be firmly secured to outside of frame, and the casement is to fasten with plain iron casement fastener and casement stay.

Solid Frame.—Fill in each window on first floor with solid wrought deal framing, having $4\frac{1}{2}$ by 3-in. beaded, rebated and water-hollowed frame, with $4\frac{1}{2}$ by 3-in. beaded and rebated head, and groved all round for lining, with $1\frac{1}{2}$ by 1-in. mould planted round on the outside ; $4\frac{1}{2}$ by 3-in. twice rebated and twice beaded and twice water-hollowed mullions 6 in. by 3 in. quirk beaded, twice sunk, twice weathered water-

hollowed and check throated oak sill, grooved for iron tongue and window board, and with 1 by ¼-in. galvanised iron water tongue bedded in white lead. Fill in with 2-in. moulded casements with 2 by 1-in. moulded sash bars rebated all round for glass, with loose beads, brass cups and screws, and having rebated hanging styles, splayed, throated, and hollow grooved bottom rail 4 in. deep with ¼-in. brass water bar screwed on, and rebated and beaded meeting styles with deal stop screwed on. Hang each casement on 3½-in. W.I. butts, and provide each leaf with two 6-in. barrel bolts, and one casement stay and one fastener to each casement.

Grounds and Architraves.—Put 2½ by ¾-in. deal splayed grounds, with 3 by 1½-in. moulded architrave mitred at angles to all doors and windows internally.

Skirting.—Form 7 by ¾-in. torus moulded skirting to kitchen and parlour, and 5 by ¾-in. plain skirting elsewhere, nailed to grounds.

Doors to be Stacked.—The whole of the doors to be knocked up and stacked together at the beginning of the contract before being glued up.

External Doors.—External doors at back and w.c. doors to be framed, braced, and ledged, hung to 4 by 3-in. solid rebated wrought chamfered frames with 12-in. cross garnet hinges. Top rail and styles 6 by 1¼ in., bottom rail 9 by 1¼ in., lock rail 9 by 1¼ in., braces 4 by 1 in. Boards to be ¾-in. V-jointed, grooved, and tongued, wrought on both sides in 5-in. widths.

Front Doors.—Front doors to be 2 in., four-panelled and double moulded, with the upper panels rebated and prepared for glass, hung on 3-in. W.I. butts to 4 by 3-in. solid rebated wrought chamfered frames.

Internal Doors.—Internal doors to be 1½ in., four-panelled and double moulded, hung by 3-in. W.I. butts to 1-in. linings, with 2 by ⅝-in. stops planted on. The linings are to be the full width of the brickwork and plastering combined.

Weather Boards.—Provide and fix weather boards to front and back external doors.

Shelving.—Provide and fix two tiers of 9 by 1-in. shelving, and one tier of 12 by 1 in., to pantries, on proper bracket bearers.

Dresser.—Fit up dresser where shown in kitchen, with central standards housed for 2-in. pot board, 2-in. dresser top with three drawers under same, and three tiers of shelving with narrow bead along front edge, and provide and fix two dozen brass hooks to edge of same.

Draining Board.—Provide and fix draining board at side of sink in sculleries where shown.

Staircase.—The staircase to be formed with 1-in. treads with rounded nosings, and ¾-in. risers properly glued, blocked, and housed into 1¼-in. wall string and 1¼-in. outer string.

Newels.—The newels to be 4 by 4-in. pitch pine, with chamfered edges, and rounded and moulded heads; ballusters to be 1 by 1 in.; the handrail to be 3 by 2½-in. birch with rounded top.

Copper Lid.—Provide 1-in. deal copper lid ploughed and tongued and having 1-in. ledge and handle, and to be well pinned with oak pins or nailed with copper nails.

Ironmonger, Smith, and Founder

Range, Fire Grates, and Mantels.—Allow £ (price list) per cottage for range and fire grates (including iron mantels to grates), and provide for fixing same.

Nails, Screws, etc.—Provide all necessary nails, screws, ties, straps, and fittings necessary for the carpenters' and joiners' work previously specified.

Cistern.[1]—Provide and fix 80-gallon galvanised iron cistern in roof where directed. Fit same with ¾-in. strong copper ball valve.

Gutters.—Provide and fix 4-in. cast-iron ogee gutter to all eaves, with all necessary angles, stop ends, and nozzles, laid to proper falls, screwed to fascia, and with joints properly made in red lead.

Down Pipes.—Provide and fix 3-in. stout cast-iron down pipes where shown with all necessary swan-necks and short pieces, with one shoot to discharge over gully, all others to connect to shoes already specified in cement. The joints are to be made in red lead, and the pipes are to be carried by strong wrought-iron stays driven into the joints of the brickwork so as to stand 2 in. clear of the walls.

Bolts and Locks.—Front and back doors are to have 9-in. barrel bolt and Norfolk latch. Internal doors to have good brass furniture, and rim locks p.c. 8s. W.c. door to have 6-in. barrel bolt and Norfolk latch.

Plumber

Lead.—All sheet lead is to be milled, uniform in thickness and free from sand cracks and other defects, and all pipes to be solid drawn and of the full weights specified.

Joints and Unions.—All pipe joints are to be proper wiped joints, and all unions are to be brass.

Pipes.—Lay ¾-in. "heavy" lead supply pipe from company's main in road to cold-water cistern with screw-down cock in an accessible position near back entrance. Take a short ½-in. branch from this pipe to supply cold water to sink.

Tap.—Fix a ½-in. screw-down tap over sink of heavy pattern for constant service.

Overflow from Cistern.—The overflow from cold-water cistern to be 1-in. "medium" lead pipe, and to discharge in open air at back.

Supply to W.c. Cistern.—Run supply from cistern to w.c. in ½-in. medium lead pipe.

[1] This cistern may be omitted where there is a constant water service.

Sink Waste.—Wastes from sink are to be 2-in. medium lead pipe with deep drawn lead trap and brass sludge screw, and are to discharge over gulleys.

Ventilating Pipe.—The outlet ventilating pipes to drains are to be 4-in. diameter of lead, equal to 5 lbs. per foot super. They are to be properly connected to drains, and to be carried full bore 3 ft. above eaves and have balloon baskets fitted on top. The pipes to be secured with tacks to the joints of the brickwork.

Closet.—Provide and fix a pedestal wash-down closet to each cottage of approved pattern with flushing rim and trap, with white wood seat, and a 3-gallon flush automatic siphon water waste preventer and cover, fixed on iron brackets and with galvanised iron chain and handle.

Overflow from W.c. Cistern.—Carry supply to this cistern from the larger cistern of $\frac{1}{2}$-in. medium lead pipe, and provide a $\frac{3}{4}$-in. overflow arm through wall finished with brass flap. The discharge pipe to closet pan is to be $1\frac{1}{2}$-in. lead, with rubber cone bound round connection in copper wire.

Gutter.—Form gutter between gables shown on back elevation and valleys to dormers of 6-lb. lead 20 in. wide, to fall at least 1 in. in 8 ft., properly lapped and secured with lead clips and copper nails, and worked over tilting fillets. Put 5-lb. lead soakers 12 in. wide to all rakes of roof where abutting, chimney stacks and dormers, with 5-lb. lead stepped flashings 7 in. wide. Horizontal flashings to be 8 in. wide, out of 5-lb. lead passed and tacked. The flashings are to be pinned with lead wedges and pointed in cement.

Dormer Checks.—Cover the cheeks of dormers with 6-lb. lead, secured with brass screws and soldered dots, and with neatly welted ends on the front edges, close copper nailed.

Soakers.—Put 5-lb. lead soakers 12 in. wide to rakes with roof, and 5-lb. lead aprons dressed over kerbs and open copper nailed.

Put to tiled dormers a 6-lb. lead soaker where ridge meets roof.

Tiler

Tiles.—The plain tiles to be whole, even in thickness, square and free from cracks and blemishes.

Roofs.—Cover the whole of the roofs with approved red tiles, laid to a $3\frac{3}{4}$-in. gauge, bedded in hydraulic lime and hair mortar, the eaves being buried in cement.

Hip and Ridge Tiles.—Provide proper plain hip and ridge tiles and proper tiles and half-tiles to break joint at verges and tilted double course at eaves. All are to be nailed with two copper nails to each tile. Make good to valleys with cement mortar.

Plasterer

Lime.—The lime is to be best white chalk lime, well slaked and screened.

Hair.—All hair is to be best long black bullock's hair, well beaten and free from grease and dirt.

Laths.—The laths are to be "lath-and-half" rent out of the heart of the best red Baltic fir, and free from sap and knots. Laths to be butt jointed, the joints frequently broken in narrow bags, and nailed with good galvanised cut wrought-iron lathing nails.

Externally.—Render external walls in two coats above string, as shown on elevations, with lias lime mortar as before described in which yellow colouring matter has been mixed to approved tints, and pebble dash with pea grit while wet. Form weathering in same to string.

Internally.—Lath plaster, float, and set all ceilings and stud partitions.

Render, float and set all internal brick walls, except those of scullery, w.c., coals, and larder.

Cement Skirting.—Run round walls of scullery and w.c. a 7 by $\frac{3}{4}$-in. plain cement skirting, formed with Portland cement and sand in equal proportions.

Angles.—Form all external plaster angles inside house with Keene's cement.

Painter, Glazier, and Paperhanger

Ironwork.—Paint all ironwork two coats before and two coats after being fixed with good oil colour, finishing to selected tints, and black all latches, hinges, grates, etc.

Woodwork.—Knot, stop, prime, and paint in three coats of good oil colour to selected tints all external and internal woodwork usually painted. All joinery, such as window and door frames, which is to be built in is to be previously primed.

Ceilings and Walls.—Twice limewhite all ceilings, and the walls of scullery, w.c., coals, and larder.

Touch up.—Touch up all work at completion.

Doors.—Glaze the small square of front doors and doors between kitchen and scullery with muffled glass properly sprigged, puttied, and back puttied.

Windows.—All windows to be glazed with 21 oz. second quality sheet glass properly puttied and back puttied.

Walls to be Stopped.—Walls to be stopped, and prepared to receive papers.

Paper.—Hang walls of bedroom with paper value 9d., and wall of parlour, kitchen, staircase, and passages with paper value 1s. 3d. per piece. Size and twice varnish the paper to kitchen, staircase, and passages.

PART II

COTTAGES AND COUNTRY HOUSES

CHAPTER I

WORKMEN'S COTTAGES

In presuming to write upon the principles which should underlie the planning of buildings, whether they be simple cottages or elaborate mansions or great cathedrals, it is necessary to disclaim any right to dogmatise.

Any one writer can only describe things as they appeal to him; but there may be many circumstances which may render his premises incorrect, or his deductions may be faulty. The subject is not one which admits of mathematical proof. Arguments, and it is believed strong arguments, will be put forward in support of the systems of planning which are to be recommended here; and an endeavour will be made to avoid the illustration of anything to which serious objection can be raised. Still, that which is right to-day may not be best to-morrow,—it would not be well if it were so. Development and improvement should, nay must, take place, and if what is here written should in the smallest degree assist such development along the lines of reason and common sense, all that is desired will be accomplished.

In the case of residences of all descriptions the principal necessity is to secure direct sunlight, at some time at least of each day, to as nearly as possible every part of the interior. Pleasant outlooks are also in the highest degree desirable; but although these may, on a balance being struck, have to give precedence to a desire for convenience of internal arrangement to suit the conditions of the inhabitants, sunlight, and ample sunlight, should in all cases be arranged for.

It will thus be seen that the aspect of a site, and the views to be obtained from it, are, or should be, prime factors in determining the plan of any residential building to be erected on it, however humble it may be.

It naturally follows that, as variations of aspect and of prospect are unlimited, so are also the possibilities of planning, each problem having to be thought out for itself if anything like successful results are to be obtained, the site being first visited and considered carefully with a view to utilising it to the best possible advantage, not merely economically, but with regard to the health, comfort, and pleasant existence of the future inhabitants of the building.

Extreme economy is also essential in a very large number of cases—economy not only in first cost, but in future working upkeep, and these economies are often antagonistic to one another. Where a small addition to the initial outlay will result in a more than corresponding reduction in the cost of maintaining or repairing the building, the additional money may be well spent; but such economies are more often to be effected by careful planning than by reduction of first cost. And this first cost, too, depends largely upon the plan.

Unnecessary passages and waste space of any kind has to be paid for, while awkward roofing, involving the use of flats or of difficult trimming and cutting, is extremely costly in comparison with any advantage which is gained.

It is thus evident that, even in buildings of the very simplest and most ordinary nature, there are so many considerations to be observed, some of which are necessarily in conflict, that considerable skill is necessary in order to devise a plan which shall best meet the needs of any individual case. This is accentuated if a building is desired that shall be pleasing to the eye, in harmony with its surrounding, and architecturally suitable both internally and externally to the purpose for which it is intended.

In no class of dwellings are the conditions so simple as in workmen's cottages, yet the opportunities for variation are endless, and it may be safely said that the ideal cottage, under any one of the numberless differing circumstances possible, has yet to be designed.

Primarily, they must be cheap. They must cost little to build, so as to offer a reasonable return upon capital expended when let at a rental such as the tenant can

afford, and this is necessarily small. The unskilled labouring man, whether in county or in town, earns so little that every penny which can be economised is of importance to him. He can, for instance, afford but one fire as a rule, unless it be a copper fire for washing, occasionally. This means that one room must serve all ordinary purposes of living, meals being there prepared and partaken of. Any additional room set aside as a parlour is valueless, being out of occupation except on rare occasions, and the space it might occupy is much better thrown into the general living room, making it large enough for comfortable occupation even by a large family.

Although a married couple without children, or with one young child, may do with two bedrooms, one for themselves and one for an occasional visitor, yet it is generally considered that at least three bedrooms should be provided in every cottage, one for the parents and one each for the male and female children respectively. These should all be large enough to contain full-sized double beds—and a small room in addition is, if obtainable, often most valuable.

A small wash-house must also be provided, together with a larder, a small store for fuel (often arranged beneath the stairs), and an earth- or a water-closet, according to whether the cottage be in a purely agricultural district or in one having a drainage system.

For economy's sake, cottages are rarely built singly, but rather in pairs or in rows of three or more, reducing as much as possible the proportionate amount of outside walling to each, which is both expensive to construct and tends to produce a cold house. For the same reason, chimneys are grouped together and arranged upon inside walls, that all the heat generated may be usefully employed, and not merely serve to warm the external air.

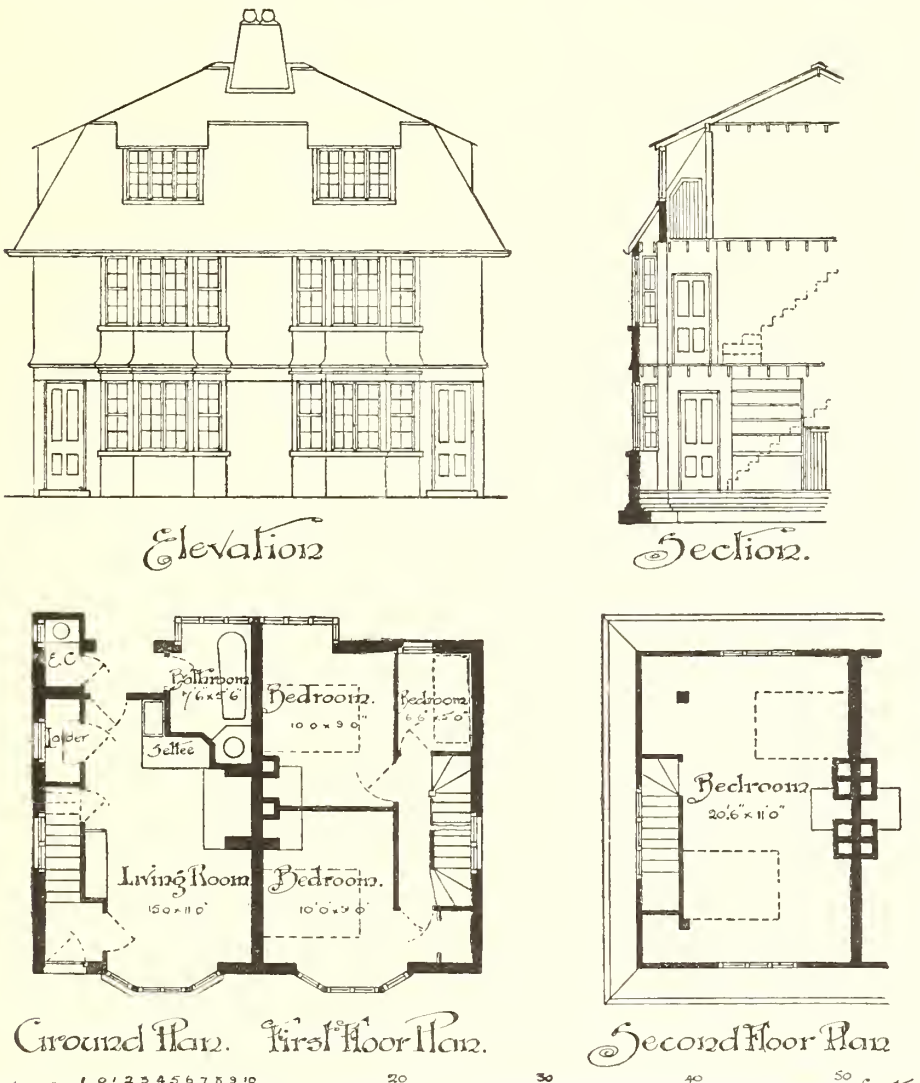


FIG. 34.

Fig. 34 illustrates a pair of cottages designed on these considerations to meet the requirements of a working man with the proverbial small income and large family, on the assumption that they face south or west, and that the best views are obtainable in front. Thus the living rooms are arranged in front, and, provided with bay windows, secure sunlight for the greater part of each day, together with a pleasant outlook. The outer door opens into a small lobby from which the stairs rise direct, while the living room is entered from it also through an inner door. A good deal of attention was here paid to the way in which these doors should open, so as to be least awkward while shielding the room from unnecessary draughts. As shown, visitors are admitted readily, while the fireplace and middle of the room are protected, and the bay window is not unduly exposed.

The living room is large enough for a family to congregate in; the front portion with its cheerful bay being arranged for the table, with plenty of space then left in front of the fire, alongside of which a settle or seat is arranged, having a high enough back to screen off the sink, which is placed here in order that the

housewife need not be compelled to carry the hot water for washing-up into the cold wash-house. The sink is in front of a window facing north. The larder, with window to east or west, is placed close to the sink, and at the fireplace end of the room, and a dresser is also accessible, while there is a small store for fuel under the stairs.

Near the sink another door leads into an open-air but covered lobby, from which the earth-closet is entered on one side and the wash-house on the other, thus securing disconnection to both, so that on washing days the steam from the copper shall not enter the living room. The copper is placed against the jamb of the living room fireplace, so as to utilise the same chimney stack, and close to it is placed a bath.

Until recently it was rarely thought necessary to provide a labouring man with the means of having a wash, but a bath is as greatly appreciated by him as by any other member of the community, and it has been found that, if put in the wash-house close to the copper, it can be filled by a tap directly from the copper, while its waste can discharge outside, either over a trapped gully connected with the drainage system, or into a small sump or-soak away. It also serves as a most convenient wash-tub, or can be covered with a table top when not in use. It should, of course, not be encased.

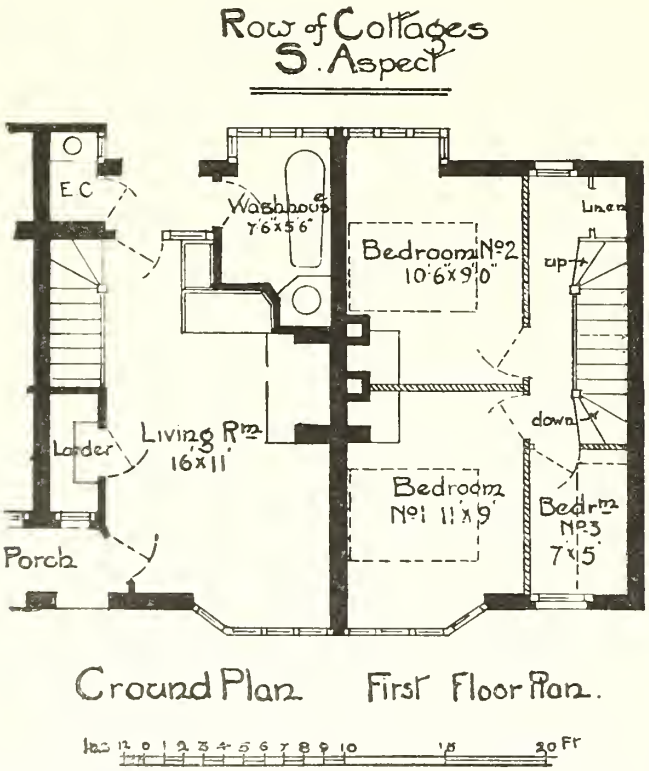


Fig. 35.

The projecting square bay gives a little additional room, and secures the entry of direct sunlight, either in the morning or evening.

The stairs are of necessity narrow and steep, but not too steep for comfort, and they are well lit with window to east or west.

On the first floor there are three bedrooms, the

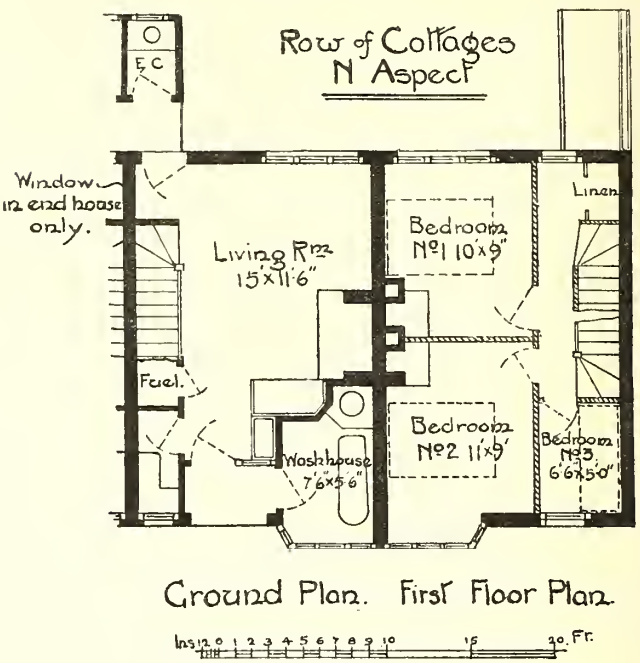


Fig. 36.

principal one, No. 1, facing south, while the bay window to No. 2 allows at any rate some sunlight to enter either in the morning or evening. Each of these is large enough for a double bed placed away from all draught; but No. 3 is as small as a bedroom can very well be. There is just room in it for a single bed, and that is all. Its window faces either east or west. A spare corner in bedroom No. 1 is utilised as a linen cupboard.

The second floor is contrived entirely within the roof, by constructing it upon the Mansard principle, with two different slopes. The whole space is given up to one large bedroom, which would contain in case of necessity as many as two full-sized beds and one smaller one, while plenty of light is admitted by windows at back and front. Posts are necessary to carry the hips where the roof pitches change, and these appear in the room.

The roofing, as will be seen from the drawings, is simple, even the bay windows being covered by overhanging the eaves of the main roof, and the attempt to obtain all that is needed at low cost is carried so far as to expose the floor joists that the height of the rooms below may be reckoned from their floor to the underside of the flooring over, the total height of the building being thus much reduced.

This type of plan is capable, without very much alteration, of being utilised for rows of cottages having exceedingly narrow frontages, as shown in Fig. 35,

each cottage having a frontage of 15 feet and a depth of 22 feet 6 inches. The modifications consist mainly in the substitution of an open porch common to two houses for the closed lobby entrance, so as to afford light to the larder, which is now brought to the front—and the other changes are necessitated by these. The stairs have to rise in the opposite direction, and directly from the living room, to which they may be open.

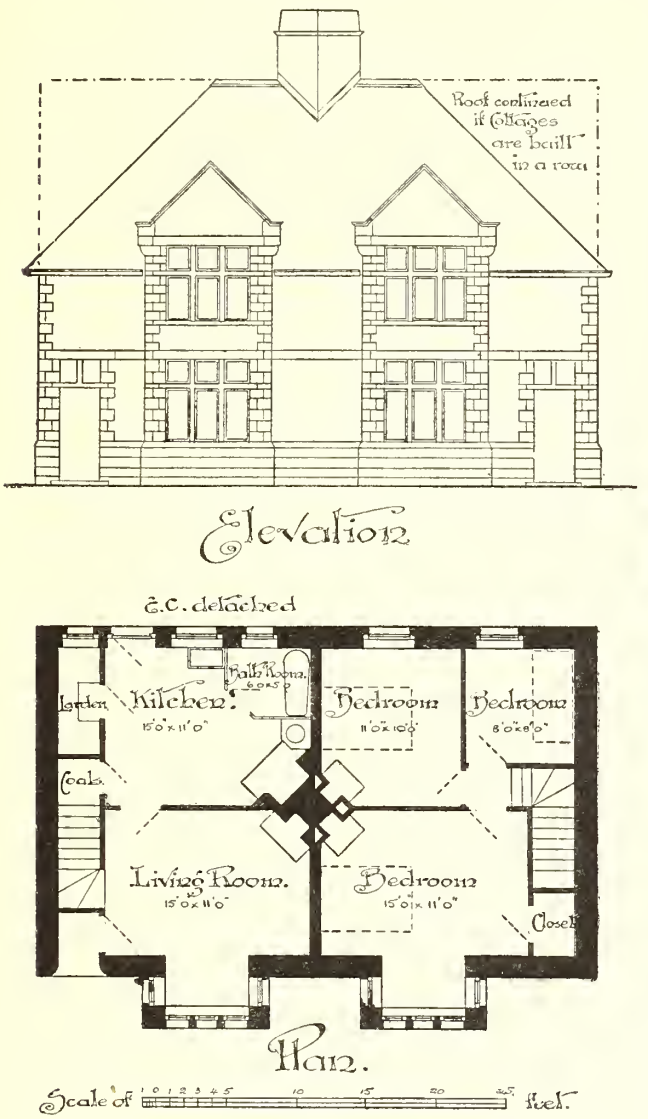


FIG. 37.

This enables the heat from the living room fire to ascend and warm the whole house; but the landing on the first floor has to be lit from the north, and bedroom No. 3 now comes to the south, while the staircase to the second floor has to be lit by a dormer window to the north, and the bay windows in the front have been altered in position and shape to prevent bedroom No. 3 from being cramped.

Once a type is established it is frequently possible to vary and develop from it to suit different conditions. Thus in Fig. 36 the plan is reversed to suit a northerly frontage, the wash-house and larder being brought to the front so as to face north, and the living room being at the back, with an external covered way to disconnect the earth-closet. In the end houses of a row built on this plan the living rooms could have end windows, looking out to east or west as the case may be.

In Fig. 37 the same type of plan as in Figs. 34 and 35 has again been used, but under less circumscribed conditions as to frontage and ground area, permitting it to be altered almost out of recognition. The principal change is the enlargement of the wash-house, the partitions between the rooms on ground and first floors now coming over one another; but this small constructional advantage is counterbalanced by the living room having become more of the nature of a mere passage room, which would only be occasionally used, meals being generally cooked and eaten in the wash-house, now

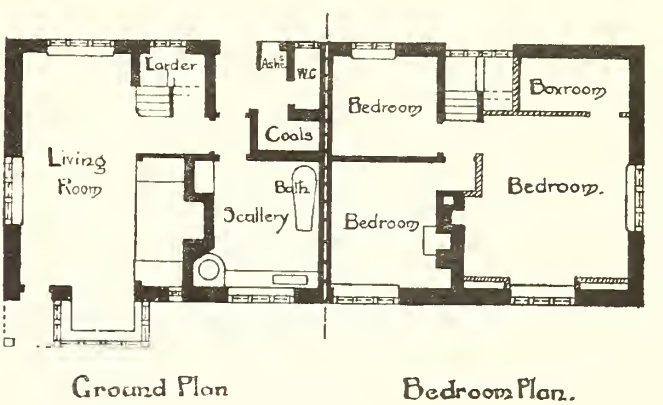


FIG. 38.

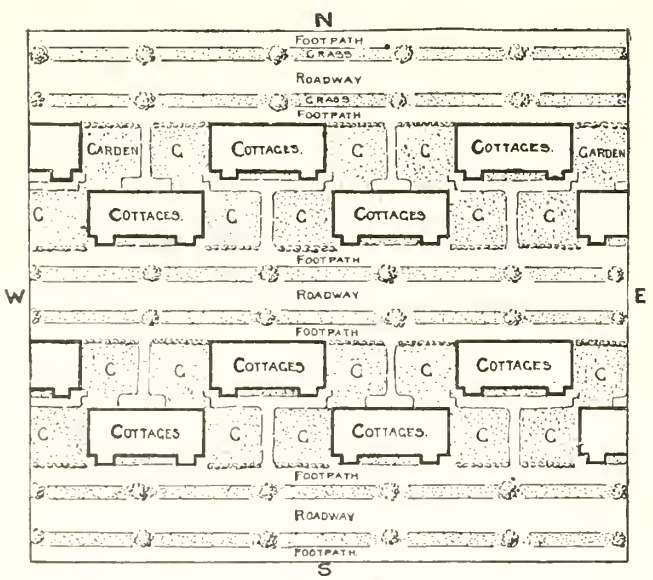
called the kitchen. Three tolerably good bedrooms have been obtained on the first floor, and consequently it has not been thought necessary to carry the building any higher. An entirely different elevation naturally results, the eaves being kept low so as to economise walling, and the windows gabled in consequence. The walls are shown to be built of stone, while the roofs are of tile.

An entirely disconnected shed is generally to be found in conjunction with such a plan as this, to serve for fuel stores and e.c.'s; an arrangement for which much cannot be said, unsightly at the best of times, and forcing the aged and the infirm to traverse the open in all weathers.

So much attention has been devoted to one type deliberately, in order to show that under changing conditions the same type of plan may often be employed with success, provided that the necessary modifications be made; but yet each type has its limits. The type

which suited a narrow frontage and small ground area has been shown to fail comparatively when applied to a more open site and a larger area. Yet a better and not a worse result should be possible under such circumstances, and so it is. Fig. 38 illustrates a pair of two-storey cottages designed by Messrs. Parker & Unwin, primarily for a site having both frontage and view to the south, yet equally well adapted for easterly or westerly main aspects. Each cottage has a frontage of about 25 feet, but the depth is only some 20 feet, so that the ground area covered is still small.

A long and narrow living room is entered directly from the porch, and extends right through from front to back, having windows at each end and at one side also. In this way all the sunlight possible is obtained, and so far as this room is concerned the aspect is not greatly material, save that what best suits one house will not necessarily suit the other so well. The fireplace is recessed in a deep ingle-nook, forming an exceedingly comfortable corner in the winter, and a little light is admitted by a small window at a high level to enable any one to read or work while sitting in the ingle-nook. The staircase is in full view of the room, yet sufficiently screened off it to prevent draught. The scullery (or wash-house) has been placed in the front, for the sake of the southern sunshine, and the coal store, w.c., and ashes are all contrived to be reached under cover through the open air, all being self-contained within the outline of the main walls—as would be scarcely permissible if there were no drainage system.



BLOCK PLAN.

FIG. 38A.

The space allotted to the stairs is not screened off, it being almost a canon with Messrs. Parker & Unwin that the stairs, the only feature of real beauty in a small house, should be exposed to view from the living room, the air space being thus made available for breathing purposes, and the staircase, and thus the

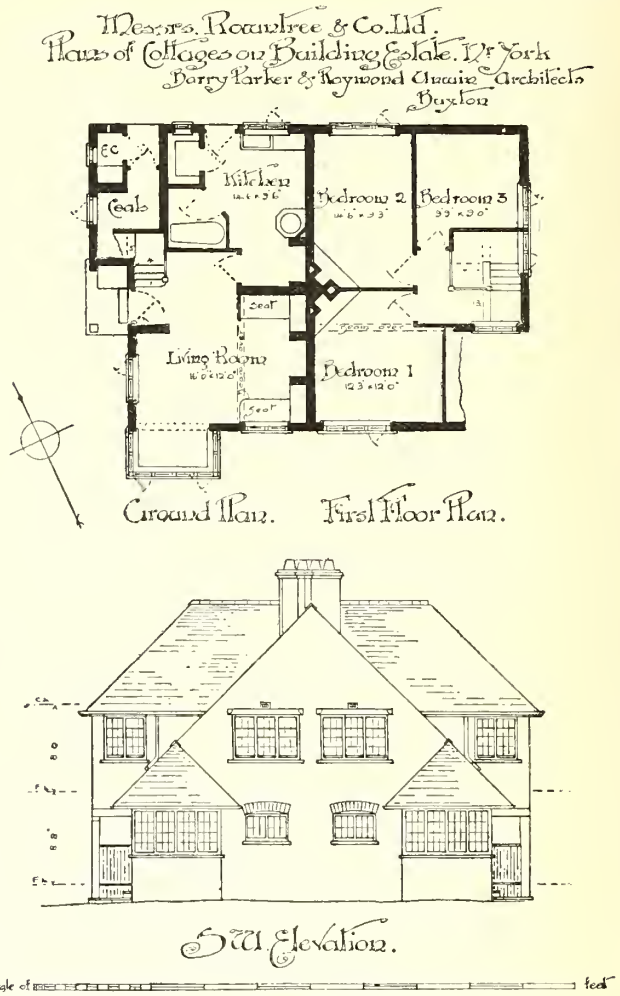


FIG. 39.

whole cottage, warmed from the living room fireplace. Certainly the room as planned in this instance would be both comfortable and pleasant to live in.

Three bedrooms and a boxroom are obtained on the first floor, with no waste of space whetever; and the large boxroom could obviously be thrown into the principal bedroom if desired.

It will be noticed that these cottages may equally well be entered from either back or front, and this was done to meet rather exceptional conditions. An estate was to be laid out for cottages on the slope of a hill facing south, and instead of placing the cottages in rows, face to face and back to back, with sordid outlooks in every way, Messrs. Parker & Unwin conceived the idea of bringing the roads closer together and building the cottages in pairs, alternately abutting against the road in front and the road behind, each being contrived so as to have an open garden in either front or rear and no direct outlook on to a neighbour's cottage without both road and garden intervening, as

shown in Fig. 38A. From whichever side the cottages were entered, however, the main outlooks were all down hill towards the south, the fullest possible advantage thus being taken of the site.

It will be noticed that there is a space between the back of one cottage and the front of another to allow a current of air to pass freely through and keep the garden plots always fresh and sweet.

When a working man's income is sufficient, as is generally that of the skilled artisan, to justify his affording the luxury of two fires in his house during winter-time, it is reasonable that the scullery or wash-house should be enlarged to the dimensions of a kitchen and provided with a cooking range, in order that meals may be partaken of in a place apart from that of their preparation. The problem thus presented is one of common occurrence, and can be fairly met by such a scheme as that prepared by Messrs. Parker & Unwin for a pair of semi-detached cottages which have been built for Messrs. Rowntree & Co. Ltd., near York (see Fig. 39). They have been planned for a southerly aspect, with pleasant views to both east and west over well laid-out front gardens and a winding road, and the living rooms are consequently placed in the front, with large bay windows from which full advantage may be taken of the views, while they admit sunlight throughout the day. The seats by the sides of the fireplace give the effect of a deep ingle-nook, but there is no reason why they should be permanent fixtures, and their omission would make it possible to place a large table in the body of the room, which is cleverly screened from any draught from the outer door by means of a short projecting wall. The staircase is again in full view, and the end of the room out of which it rises would form a passage way between the front door and the kitchen, which, without being screened off, is sufficiently defined to prevent the disturbance of the whole room by constant passing to and fro.

The sink would now be placed in the kitchen, which in such a house as this would be in constant use, so that some method of screening off the bath, when required, would be necessary. This is done by means of a folding screen, with openings for light and ventilation at the top, so that the screen can be thrown back and the bath opened to the kitchen, and either covered by a table top or utilised as a washing trough.

The kitchen has a door leading directly into the back garden, and so out to the **e.c.** and coal store, which are both within the house walls, while the pantry opens out of the kitchen.

On the first floor three rectangular and comfortable bedrooms are obtained without waste of space, while the simple grouping of the chimneys into one stack is very noticeable, all the fireplaces being in the corners of the rooms. This is often the best possible arrangement, very little space being occupied and the heat being radiated directly over the whole room.

It may, in parentheses, be here remarked that 9 by 9-inch flues are quite large enough where coal, and not wood, is the fuel burnt, and that fireplace openings $13\frac{1}{2}$ inches wide are quite sufficient for small bedrooms if fireplaces of modern form are used.

The simple way by which such a building may be roofed is sufficiently indicated by the elevation, which has been carried out with rough-cast on brickwork, the roofs being of red tiles.

CHAPTER II

SMALL COUNTRY HOUSES

Houses for the middle class differ from those of the working community in so marked an extent that an entirely different system of planning is necessary. Even in the smallest middle-class house the work of the house is done by a servant, who, though closely supervised and probably assisted by her mistress, lives apart from the family. Such a house, however cottage-like it may be in appearance, is consequently a dual dwelling, essentially different from the cottage proper, in which all the work is done by the housewife.

The family require at least two sitting-rooms, one for meals and the other for recreation, while the servant lives in the kitchen. Even very small houses of this description need four bedrooms, one having to be given to the servant, while a separate bathroom on the bedroom floor is a necessity to modern life, with hot and cold water service.

Such was the problem—one which is constantly being met with—which Messrs. Parker & Unwin set themselves to solve for Mrs. Rawnsley, at Appelthwaite in Cumberland, on a site which fell from north to south, with the principal views ranging from south-east to south-west, but the road, and almost necessarily the entrance, on the north-west.

For the sake of economy it was desirable that there should be one simple main roof, and the plan took a long narrow form in consequence, with the two sitting-rooms in the best position to secure sunlight and views, one of them breaking out as a gable to make it large enough for the requirements of a dining-room. The kitchen also needed a window which sunlight might enter at some period of the day, and this was put on the south-east, with the result that the room would not become unbearably hot during summer.

With these essentials to work upon, the plan, with its clever compactness and well-considered details, was gradually evolved, for it will be already understood, from what has been said about workmen's cottages, that a really good plan, even for a simple building, is not devised without much painstaking. The front door enters from a covered porch into a square hall, just large enough to contain an angle cupboard or hat-stand, and the living room (corresponding with what is generally called the drawing-room), the dining-room and the kitchen all open directly out of it, while down a few steps, under the stairs, is a passage to the e.c., under cover, well screened, and yet provided with proper fresh-air disconnection between two doors.

In a small house the little things of planning go so far to ensure comfort that they need a great deal of attention. The way in which doors should open, their positions in the wall, and the corresponding positions of fireplaces and windows are all matters of real importance. In the house which we are now considering it will be noticed with what care the space round each fireplace has been screened from draught, while at the same time it is well lit, for reading or working in the sitting-rooms, and for cooking in the kitchen. The large recessed hearth-fire in the living room would, too, be pleasant to look upon; and in the dining-room great pains has been taken to so place the fire that it may give direct radiant heat over almost all the room, while it is not too close to the back of anyone who may be seated at the dining-table.

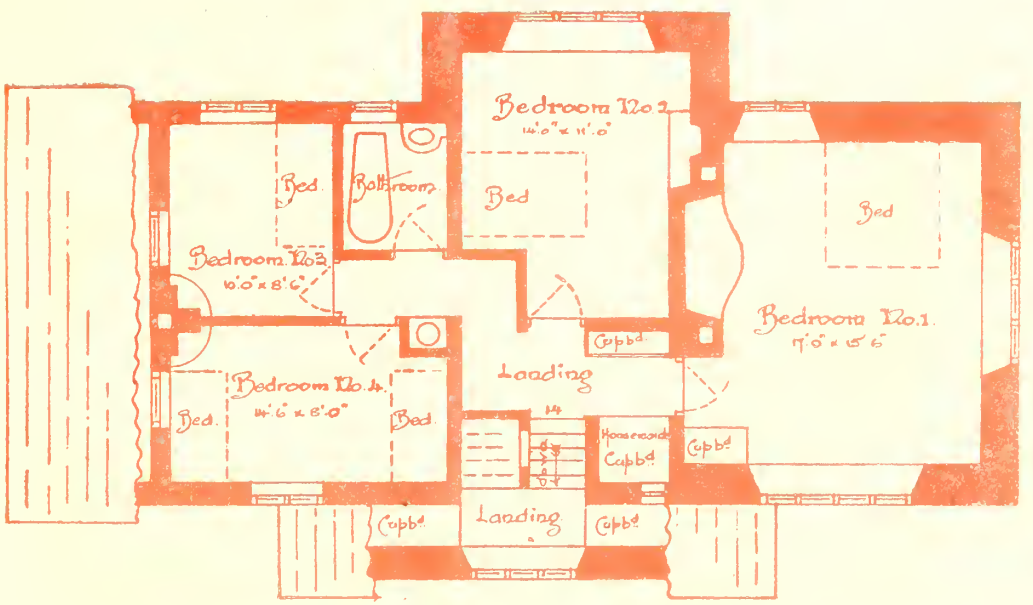
Service from kitchen to dining-room would take place through a small pantry, and both coals and larder can be reached under cover in the open air, the larder being on the north-east—the coolest—corner of the house.

The first floor contains four bedrooms and a bathroom, so placed that the waste water from the bath and lavatory basin may discharge over the same gully, and thence to the same sump or soak-away, as the wastes from the sinks in kitchen and pantry below. Several cupboards are provided, and a special recess for the hot-water cylinder. The house has been built of rough blocks of green slate from the local quarries.

The first-floor plan is printed on a flap of tracing paper to illustrate how sketch plans are first prepared in an architect's office. Often several flaps of tracing paper are used, one for each floor, pinned on to the drawing board by two pins each on the upper edge, and each somewhat larger than the one below. The ground floor is planned on the drawing paper underneath, and the other floors each on a flap which can be thrown back at any moment and work resumed on the lower floor plan.

This method of working is capable of a good deal of extension, and enables the designer to obtain a grasp of his building as a solid entity which is impossible in any other way without making a scale model of it.

The house for Mr. Conrad North in Argyllshire, from the designs of Mr. E. G. Walker, which is illustrated in Fig. 41, presented a very similar problem, both in accommodation, aspect, and prospect, though somewhat larger rooms were required, and a comfort-



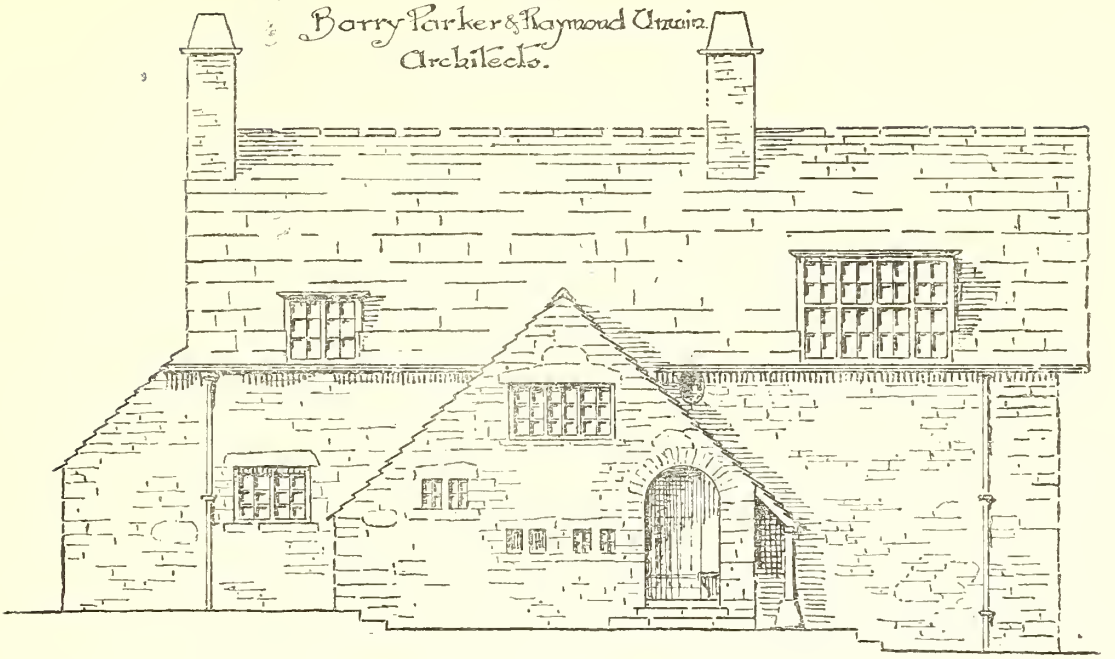
First Floor Plan.

First Floor Plan.

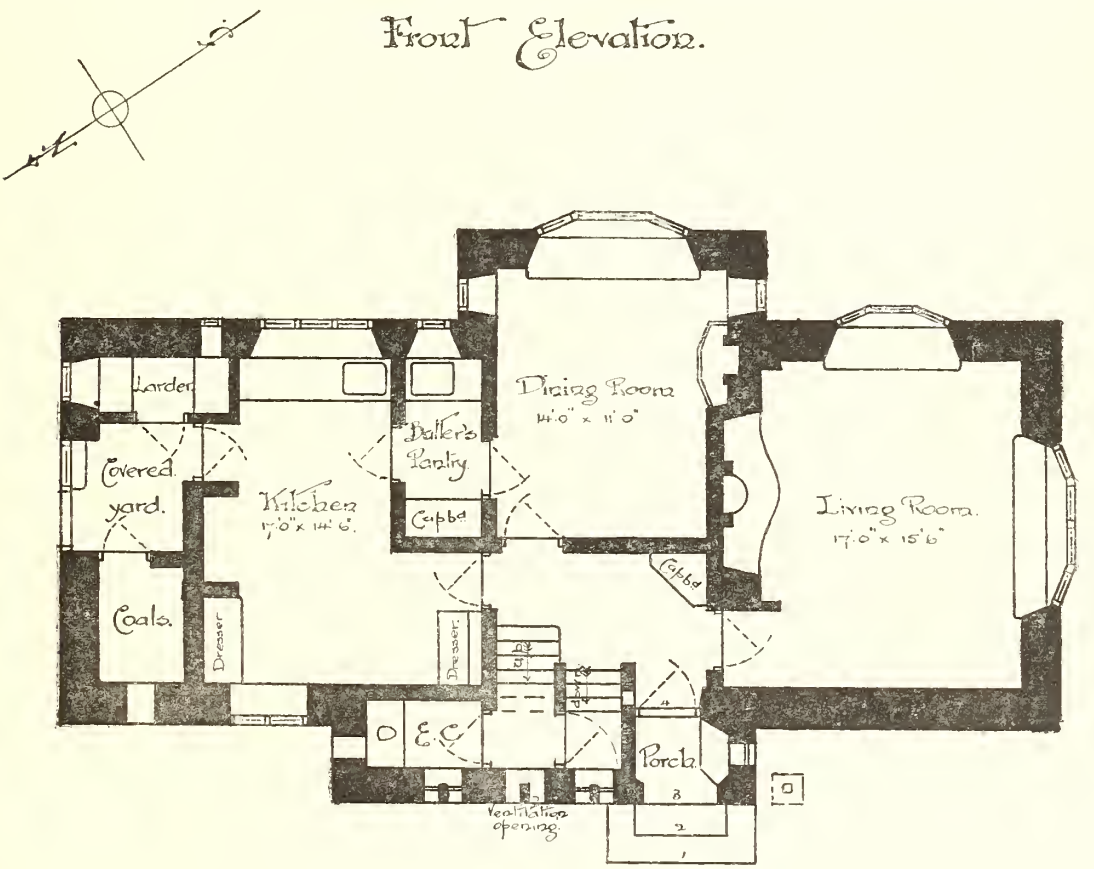
Cottage for Mrs Ramsley.

Applethwaite, Cumberland.

Barry Parker & Raymond Unwin
Architects.



Front Elevation.



Ground Plan.

Scale of feet.

FIG. 40.

able inner hall, which to some extent might be used as a sitting-room. To keep the kitchen so disconnected that the smell of cooking shall not penetrate either to dining-room or hall has been made the keynote of the plan, this being managed in the one case (Fig. 40) by the intervention of pantry and back passage, through which meals would be served, and in the other (Fig. 41) by building a screen wall across the hall under the stairs, and specially lighting the passage thus formed, which serves to give access to the front door from the kitchen, and also to disconnect the lavatory and w.c.

The best views are to the south and west, the dining-room, drawing-room and hall bay window, all looking out on to very beautiful and typical Scotch scenery, the north-east being screened from the cold winds by hills at the back.

The upper floors are simply contrived, fitting easily without waste over the rooms below, while advantage of a little space within the roof has been taken to introduce a second bathroom for the use of the servants, a luxury which is absent from many a larger house.

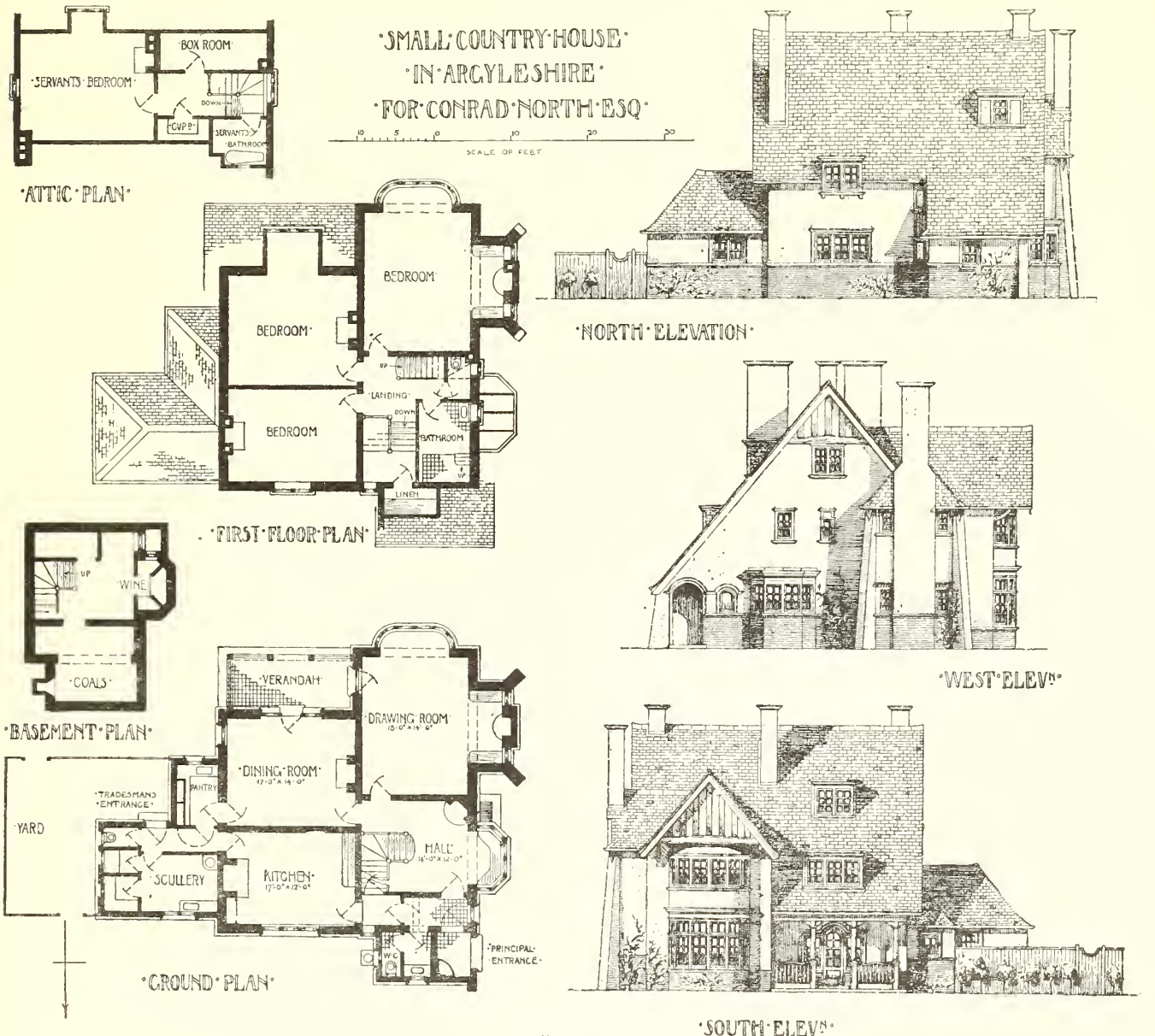


Fig. 41.

In the Vicarage at Thornthwaite (see Fig. 42) Messrs. Parker & Unwin found themselves confronted with a problem, always a difficult one, which is of very frequent occurrence—that of providing a house having three sitting-rooms and servants' quarters on the ground floor, and five bedrooms over, preferable on a single floor. Owing to the position of the site in regard to the road, the main entrance had to be

placed facing north, and a good north elevation was essential, while the principal views were to the south-east, and a rising hill cut off all outlook to the west.

Rigid economy had to be practised, that the Vicarage, while being a presentable building, might not cost much to build nor much to keep up, either in repairs or in the number of servants employed.

A T-shaped outline was chosen for the plan, that the roofing might be simple while affording some opportunity for pleasant grouping, and the house was so placed on the site as to display this from the road, the entrance being contrived in one of the re-entering angles, and all the sitting-rooms ranged to face

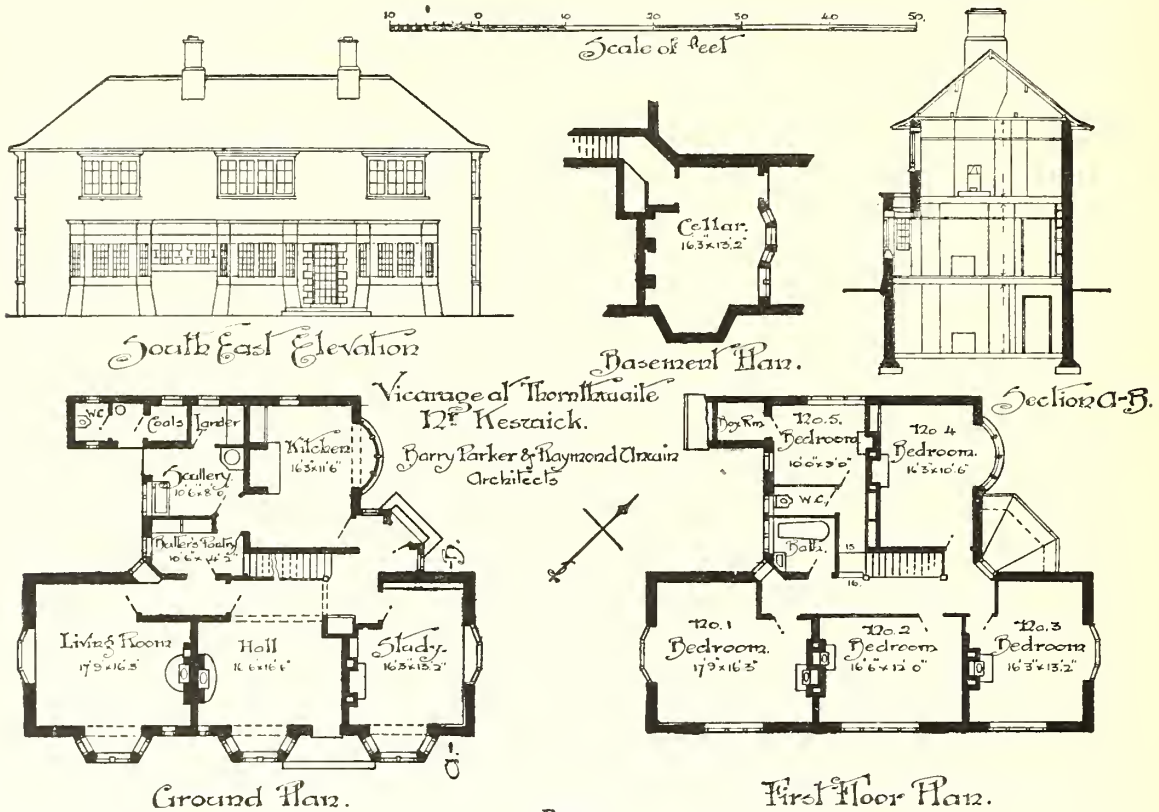


FIG. 42.

living room, without obtruding the servants upon any visitors in the hall, is worth a good deal of attention, also the clever means adopted for lighting the short passage between pantry and living room.

Similar means of lighting have been adopted to the first-floor landing from which the four principal bedrooms are entered, while the fifth is placed down a passage. Bedroom No. 1 could be easily isolated in case of illness by hanging a sheet soaked in carbolic acid across the landing, and keeping the window open in the corner. It is the sunniest room in the house, and thus admirably suited for either a sick chamber or a day nursery, both being uses to which

directly towards the pleasant south-east aspect. The staircase was placed in the middle of the house, and the kitchen in its northern corner, a circular bay being thrown out to catch a little of the morning sunshine.

As is usual with Messrs. Parker & Unwin's plans, the staircase is in full view of one of the sitting-rooms, which they call the hall. It would be used for receiving guests, much as a drawing-room generally is, while it would have a hospitable and pleasant look.

The study is necessarily near the entrance, that parishioners may be admitted without crossing the hall, and the way in which this is managed, as well as service from kitchen to front door and kitchen to

in course of time it would probably be put in a country vicarage.

Except with regard to the site, the problem presented by "Broadmead" on the Norfolk Broads, for which two distinct schemes are illustrated in Figs. 43 and 44, was of a very similar character. The house was to be on rising ground facing south, and having extensive views to the south and west, while, under the first instructions received, it was to be extremely plain in character, and contain three sitting-rooms, a large hall, kitchens, and six bedrooms. It was to be used principally as a summer residence.

Thus the first scheme (Fig. 43) shows an outer hall, from which both library and drawing-room are entered,

itself well lit and with a fireplace, all designed to give the idea of hospitable welcome, while an inner hall is reached through a glazed screen. From this the kitchen and dining-room are reached, easily accessible one to the other, while light is obtained from a tall staircase window shown on the first-floor plan. For the sake of the views and the sunlight the plan is arranged in receding steps, and a good deal more advantage of this might possibly have been taken than was done, especially in the library and dining-room. Both of these rooms, as it is, are difficult to treat internally with satisfaction, while rearrangement of the fireplaces and windows might have made them much more pleasant and comfortable too.

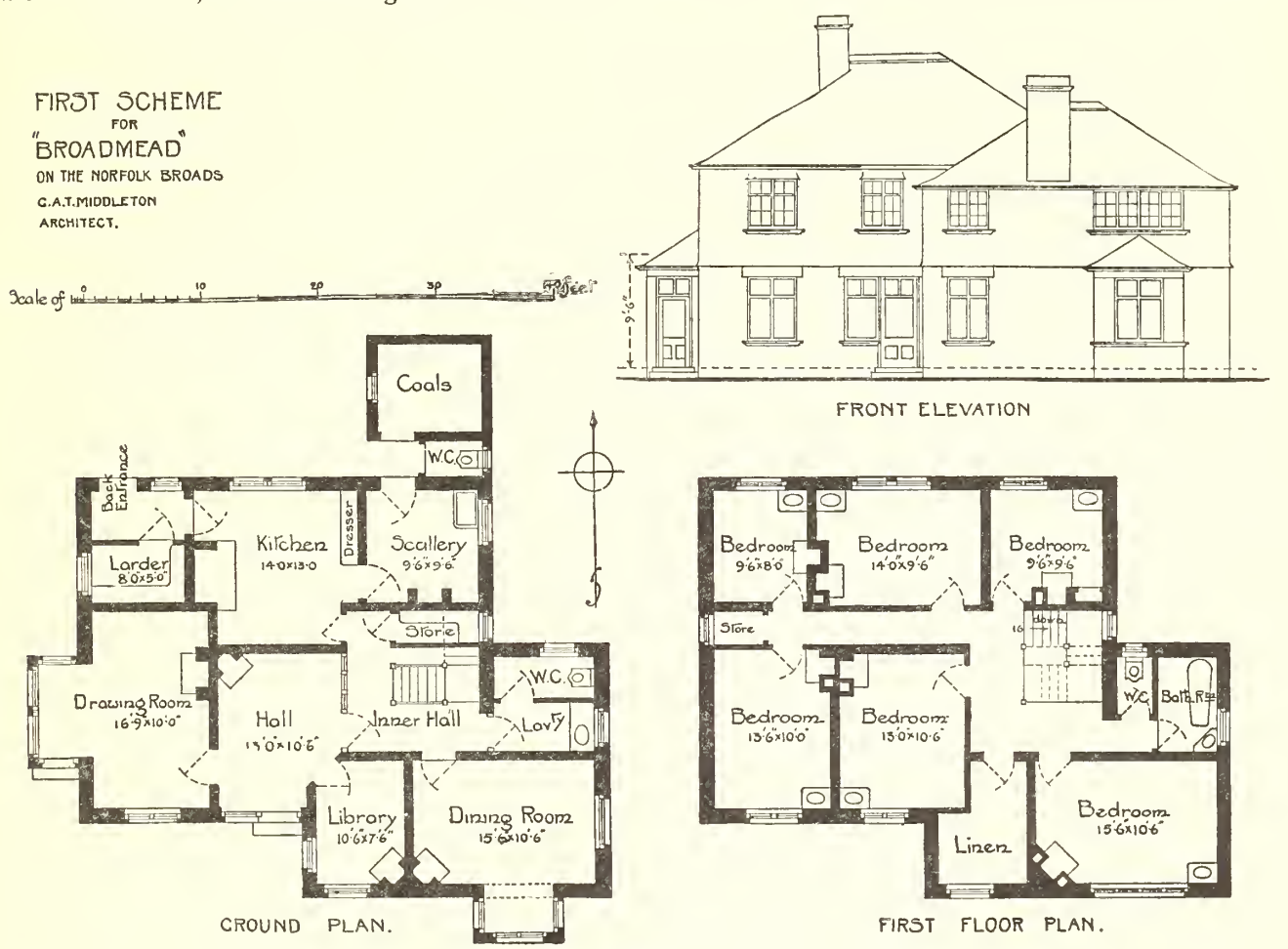


FIG. 43.

The first floor is perhaps better, though there is a certain amount of space wasted in the long passage, which is not very well lit; but on both floors the w.c.'s are well cut off from the main building, and are nearly over one another. Every bedroom, it will be noticed, has a fixed lavatory basin for hot and cold water, the desire being to work the house with as few servants as possible, and not to have much movable furniture in it.

Had it been built, further attention would doubtless have been paid to planning details, and it would have proved comfortable to live in, though extremely commonplace externally; but it is illustrated here as a preliminary sketch, to show how schemes may develop from first ideas.

Consultation with the owner, however, showed that it would be preferable to increase the size of sitting-rooms, particularly the drawing-room, and to amalgamate the inner and outer halls, while it was thought that quite a small scullery would suffice, and that a large pantry would be more useful than a small storeroom. A piece of tracing paper was then put over the plan of the first scheme, and the second scheme (Fig. 44) was evolved from it. This has a rectangular outline, the sunlight and views being obtained, by rearrangement of the rooms, in a much more simple manner. The hall is still spacious, but the staircase rises directly out of it, and underneath the stairs, well screened, is a lavatory and w.c. Service from kitchen to dining-room is even easier than before, and all the rooms are in themselves more comfortably arranged and more capable of satisfactory decoration. The angle fireplace in the dining-room is intentional, that nobody need have his back

directly to the fire at meal times, and a side light is in every case given for reading by when sitting in front of the fire.

Side light, too, is secured to the kitchen range.

A low additional piece contains the larder, with its window to the north, coals, a pumproom over the well, and the servants' w.c. and back entry.

The rectangular general outline of the plan is even more evident on the first floor, where the large linen-room of the previous scheme is sacrificed but much better bedrooms are provided, in shape particularly, and very little space is lost in landings.

Messrs. Parker & Unwin's house at Minehead, shown in Fig. 45, is an example of successful treatment under extremely difficult conditions of aspect and view. A steep hill rose to the south and west, shutting out all view in that direction, and even throwing shadow over the site after an early hour in the afternoon, while there was an extensive and beautiful prospect to the north-east, and the roadway was on the north. Good views of the site were obtainable from the east and north-east only. Stables formed part of the scheme.

For the house itself an L-shaped plan was adopted, with all the sitting-rooms in the east wing, and the

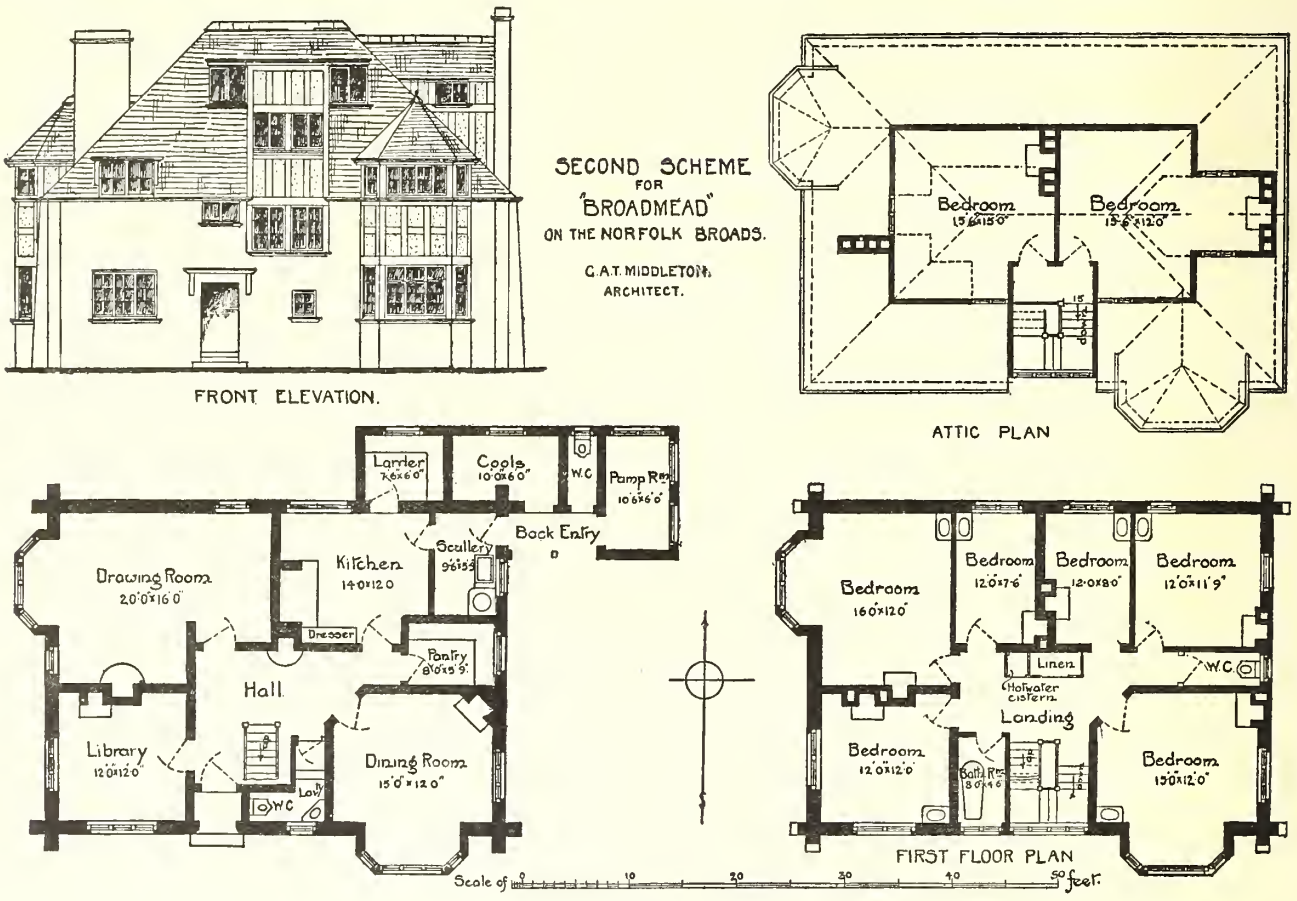


FIG. 44.

Two more bedrooms are also obtained as attics in the roof, which is steep.

Externally the great simplicity is broken by bays and by a large dormer containing the staircase, which would also serve to screen the necessary pipes from the bath-room and the outlet ventilator to the drainage system — always difficult features to deal with when the w.c.'s or baths are planned in the front of a building. Buttresses, too, were introduced at the angles to resist the thrusts from the hip rafters, and the whole result is to obtain a more interesting front on this simple plan than was possible with the original, and apparently more elaborate, scheme.

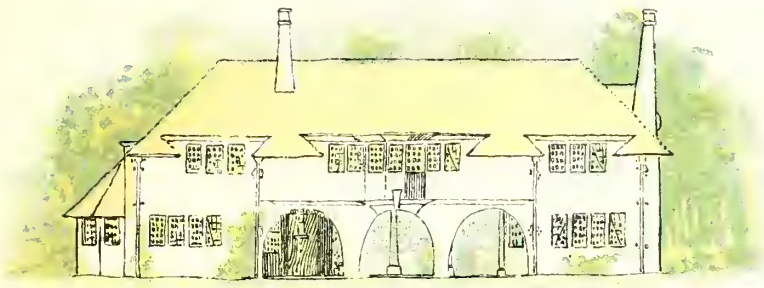
kitchens on the south, while yards and a pergola (or space arranged for climbing plants) on the west and the group of stables on the north-west closed in on three sides a small formal garden, a covered way round which enabled a carriage standing near the harness-room to be reached from the front door entirely under shelter.

A little study of the plan will show how advantage has been taken, not only of the natural prospects, but also of those artificially created by the formal garden, covered way, and pergola, extremely pleasant outlooks being given to every room, including the kitchen, which is in regular occupation. Doubtless many people would

PLATE V.

HOUSE AT HASLEMERE SURREY · FOR J·ASHWORTH·E
BARRY PARKER & RAYMOND UNWIN
ARCHITECTS · BUXTON · DERBYSHIRE

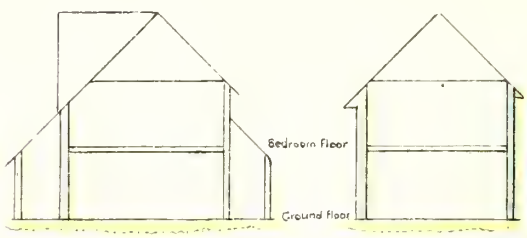
WEST ELEVATION



EAST ELEVATION

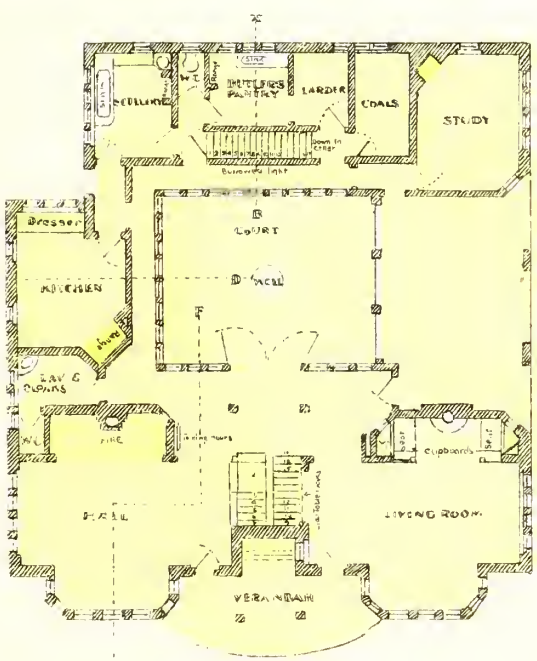
NORTH ELEVATION

SOUTH ELEVATION

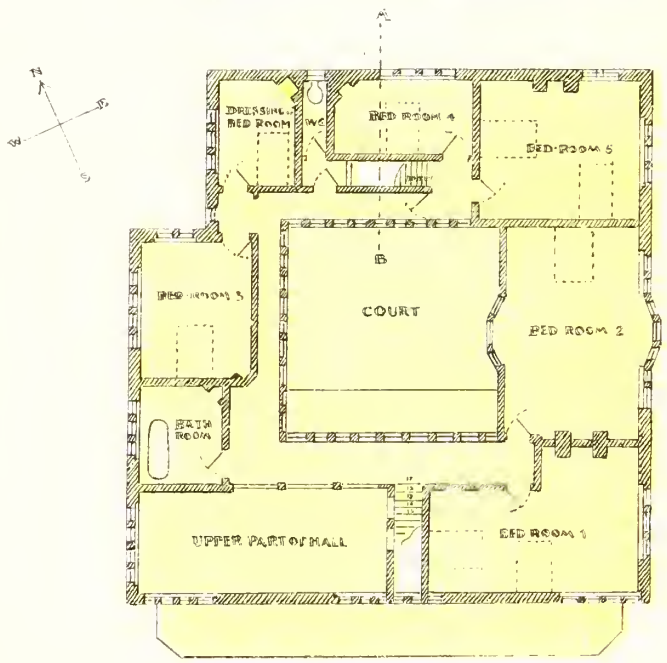


SECTION THRO E·F.

SECTION THRO A·B·C·D



GROUND PLAN



BED·ROOM PLAN

prefer that the dining-room and living room should be more definitely separated from one another and from the hall, the inconvenience of having the only staircase of a gentleman's house in view of the reception-rooms being great; but the gain in appearance is considerable, vistas, otherwise unobtainable, being opened up. Similarly the arrangement on the upper floor, by which bedroom No. 1 is only to be reached through a dressing-room and across a gallery from which both the staircase and living room are visible, might be extremely objectionable. Even where it is needed by exceptional circumstances, such an arrangement is rarely permissible unless easy means of alteration are provided.

Bedrooms Nos. 3 and 4 would form an isolation wing in case of sickness, by hanging a curtain where the dotted line is shown.

The house which the same architects designed for Mr. Ashworth at Haslemere (see Plate V.) carries the idea of a courtyard still further, it being there entirely enclosed and surrounded both on ground and first floor by a well-lighted corridor from which all the rooms have access. This system of planning, common enough on the Continent, is rare in England, and results, unless the whole of one side of the court be open on the ground floor, in stagnant air collecting in the corners; while a good deal of trouble has to be taken to admit sufficient sunlight to the courtyard for our climate.

The exposure of the staircase to the hall—which is so planned as to be really a sitting-room—would probably be less objectionable in this case than in some others, as a secondary staircase is provided which could be used by servants and children; but unquestionably both the stairs and the balcony would be beautiful features. Pleasing vistas are arranged across the court in several directions, and internal communication is naturally easy with such a plan, which is perhaps best suited for a bleak situation.

The coloured illustration, reduced from a drawing of considerable size, is shown to indicate successful colour treatment of what, though prepared in the first place as sketches to lay before a client, are perfectly capable of being used as working drawings. There is much use made of white paper and simple washes, effect being added by a little clever use of the brush.

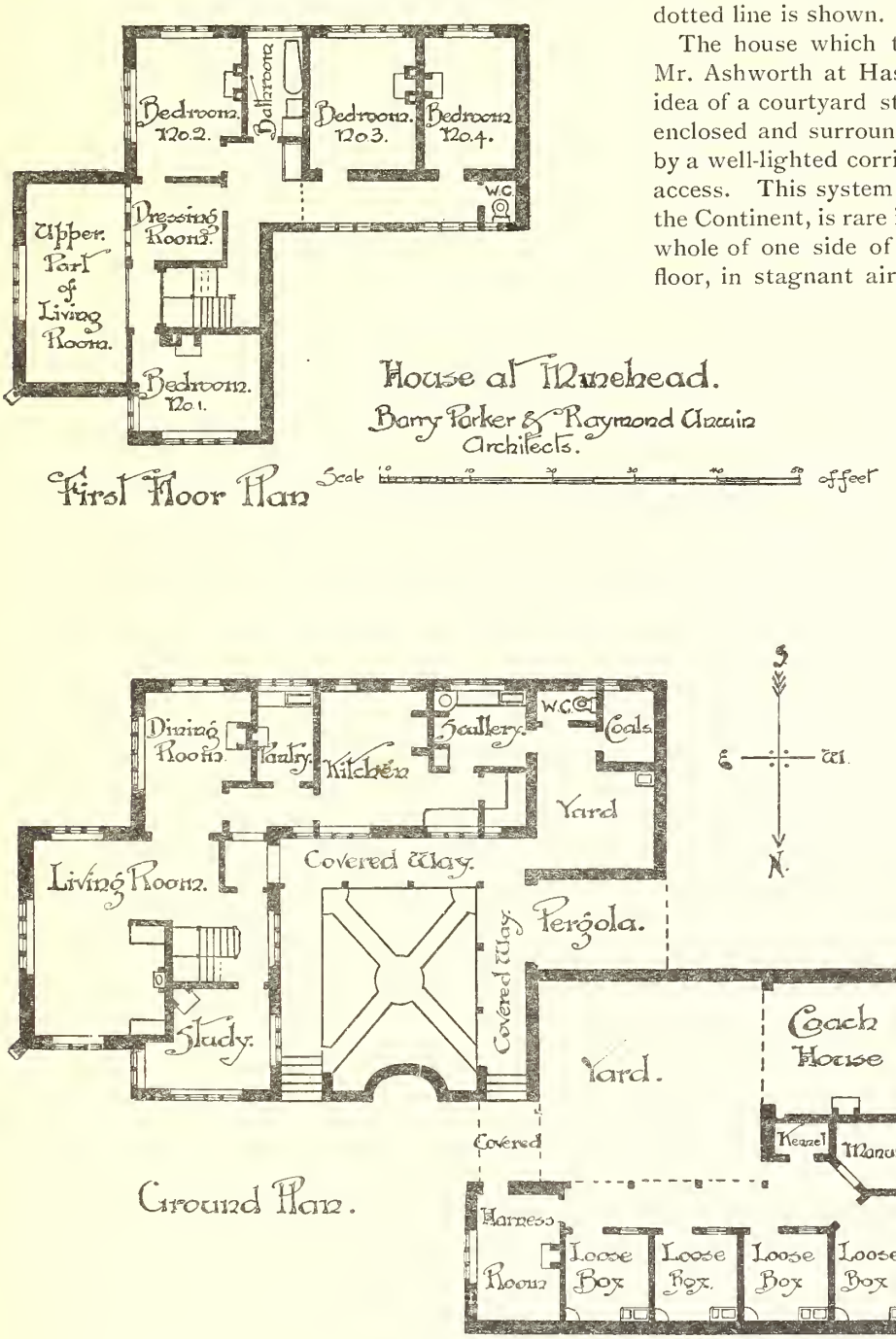


FIG. 45.

CHAPTER III

LARGE COUNTRY HOUSES

As houses are built of all sizes, to suit an infinite variety of conditions, it is difficult to classify them; but perhaps it will be generally conceded that a large country house is one in which extreme economy is not a primary condition, and one, moreover, in which the servants' quarters are entirely distinct from the family residence. This is, in fact, essential where any considerable number of servants are kept.

Thus something of a formal and dignified character becomes both possible and right, such as would be out of place in a small house. Large rooms take the place of small, with definite architectural treatment of each, and the addition of many a minor convenience.

Still, every point to which attention has already been drawn must be observed. The house must be capable of being constructed and roofed with ease, while aspects, prospects, and such details as the relative positions of doors, windows, and fireplaces are all of just as much importance in a large house as in a small one.

The problem, therefore, is an expanded problem rather than a new one, and has several recognised solutions, typical examples of which have been selected for illustration.

"Britwell," Herts (shown in Fig. 46), designed for Sir John Evans by Messrs. Hubbard & Moore, is an example of axial planning, such as is usually employed for larger works, and has many centuries of custom to recommend it. Architecturally no system is more successful.

If a centre line be drawn from back to front it will be noticed that it passes entirely through openings forming an axial vista through the house when the doors are open. To right and left of this the exterior is symmetrical, although the plan, which is in outline based on the letter H, is necessarily varied on either side internally.

The main entrance is on the north,[1] under a "porte cochère," or porch of sufficient size for a carriage to stand in it, and to afford protection from the north wind. This opens directly into a square hall, the evident intention being to give an impression of dignity. The stairs are not visible from the hall, but rise on its left behind an intervening wall, being balanced by a strong-room similarly placed on the right.

[1] It may be interesting to note that the house has been set out on the ground to the true and not to the magnetic meridian—that is, the axial line is almost correct to the north star, and not to the compass needle, which is always inaccurate, varying from time to time, and at present pointing some 17 degrees west of true north.

The drawing-room door opens centrally out of the hall immediately opposite the entrance, for reception purposes, and the room, facing south, opens on to a loggia.

The large library is an unusual feature, and is planned so as to be easily converted into two rooms — study and billiard-room, for example — if desired. It extends from back to front at the west end of the house, thus enjoying sunlight all the afternoon. The bookcases are arranged to give plenty of storage room under the best possible lighting conditions, while leaving the middle of the room free for reception purposes or for a billiard table.

The corresponding wing to the east is given up, in front, to a large boot or cloak-room with lavatory and w.c. for gentlemen, and at the back to the dining-room, which is wide enough for the fire to be placed centrally without serious discomfort. The communication door with the drawing-room, enabling the ladies to retire after dinner without traversing passages, will be noticed, as will also the proximity of the door from the corridor to the gentlemen's lavatory. A third door to the dining-room is intended for servants' use only, opening at the end of the servants' corridor in what is, to all intents and purposes, a separate house containing the kitchen and the servants' quarters generally.

The kitchen and pantry are both in close proximity to the dining-room, though so placed that no smell of the cooking would penetrate, and the butler's bedroom is reached through his pantry, and contains a safe for the deposit of plate. This room, and also the servants' hall, face south, while the kitchens and larders are, for the sake of coolness, kept on the north.

All these are the usual arrangements of a large house, though they have been planned in this case with unusual simplicity and skill, while the hall to the back entrance gives more comfort to the servant's quarters than is often met with.

The w.c. for the women servants is placed near that of the main building for ease of drainage, and is under the servants' staircase, which rises and turns into the main building on the first floor, which does not extend over the servants' annexe. It is given up to a few good bedrooms, including a suite of three rooms for nursery use, though so planned that both the day and night nursery could be used as a bedroom, and each be provided with an adjacent dressing-room—

a luxury not to be found to so large an extent in many houses.

The second floor is reached by the servants' staircase only, and contains enough bedrooms for several visitors' servants as well as those belonging to the house. Each room is so planned that the bed could be placed out of the draught between door and window.

The house near Rye (see Fig. 47), designed by Mr. Reginald Blomfield, A.R.A., is of much the same size but less formally treated, with almost the same aspects. The axial arrangement has here been abandoned, and

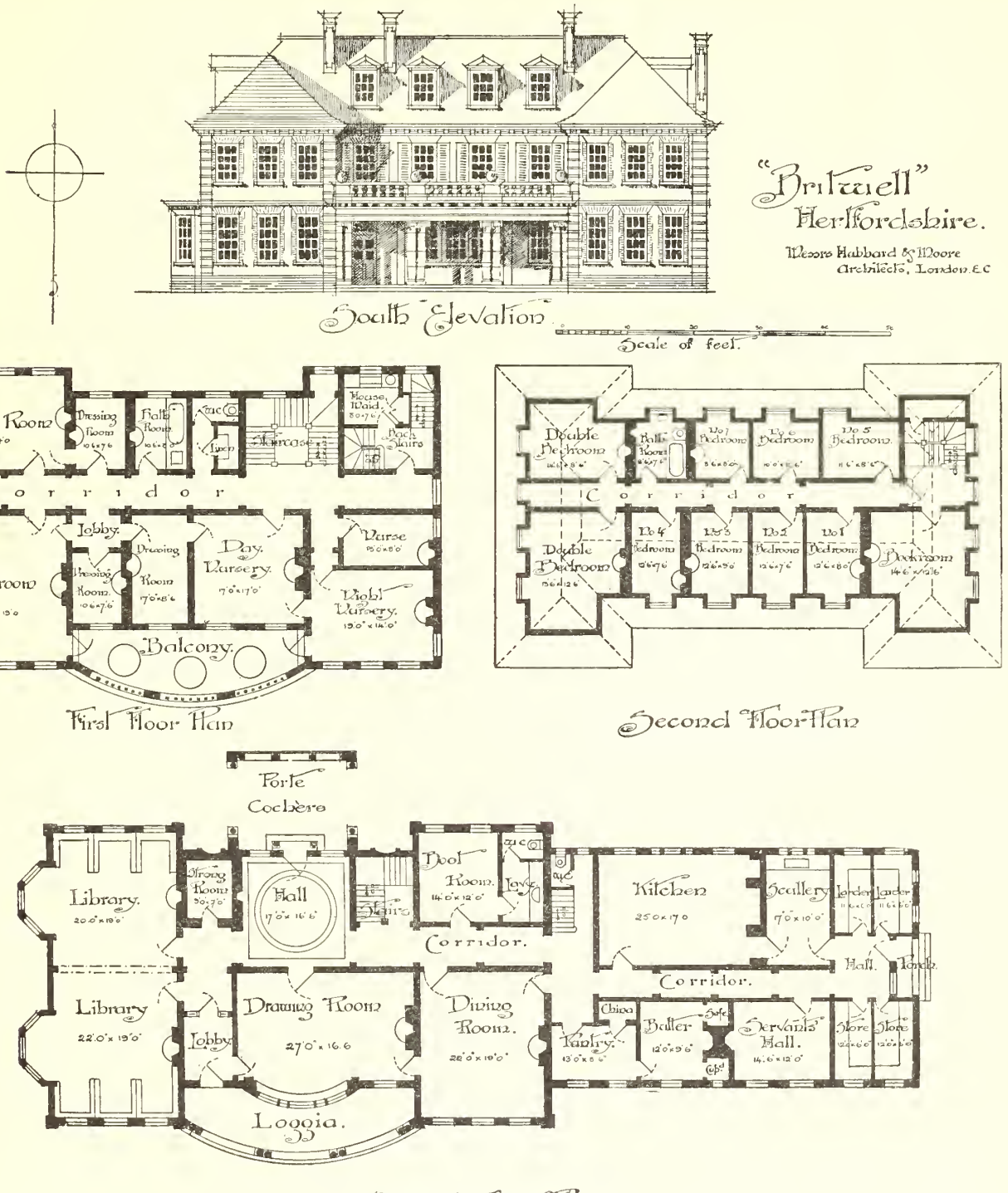


FIG. 46.

a large well-lit hall provided out of which the staircase rises; otherwise the ground plan of the main block is very similar indeed to that of "Britwell." The servants' annexe, however, in two long wings, is quite different, the central corridor lit from the ends being replaced by a side-lighted corridor with rooms on only one side of it. As a result more ground is covered, and the kitchen is farther from the dining-room; but the corridors are better lit and ventilated. There is a lift for coals from a basement coal-store right up the greater importance, on account both of its size and of the many lessons to be learnt from its plan.

The site (see Fig. 47A) was of considerable area, near the top of a gently sloping hill which fell away towards the south-west, from which position the house is seen to best advantage. The location of the house was selected with great care, that it might command extensive views and be itself a prominent object, while to its south-east and south-west, in full view of the principal rooms, terraced lawns and flower gardens

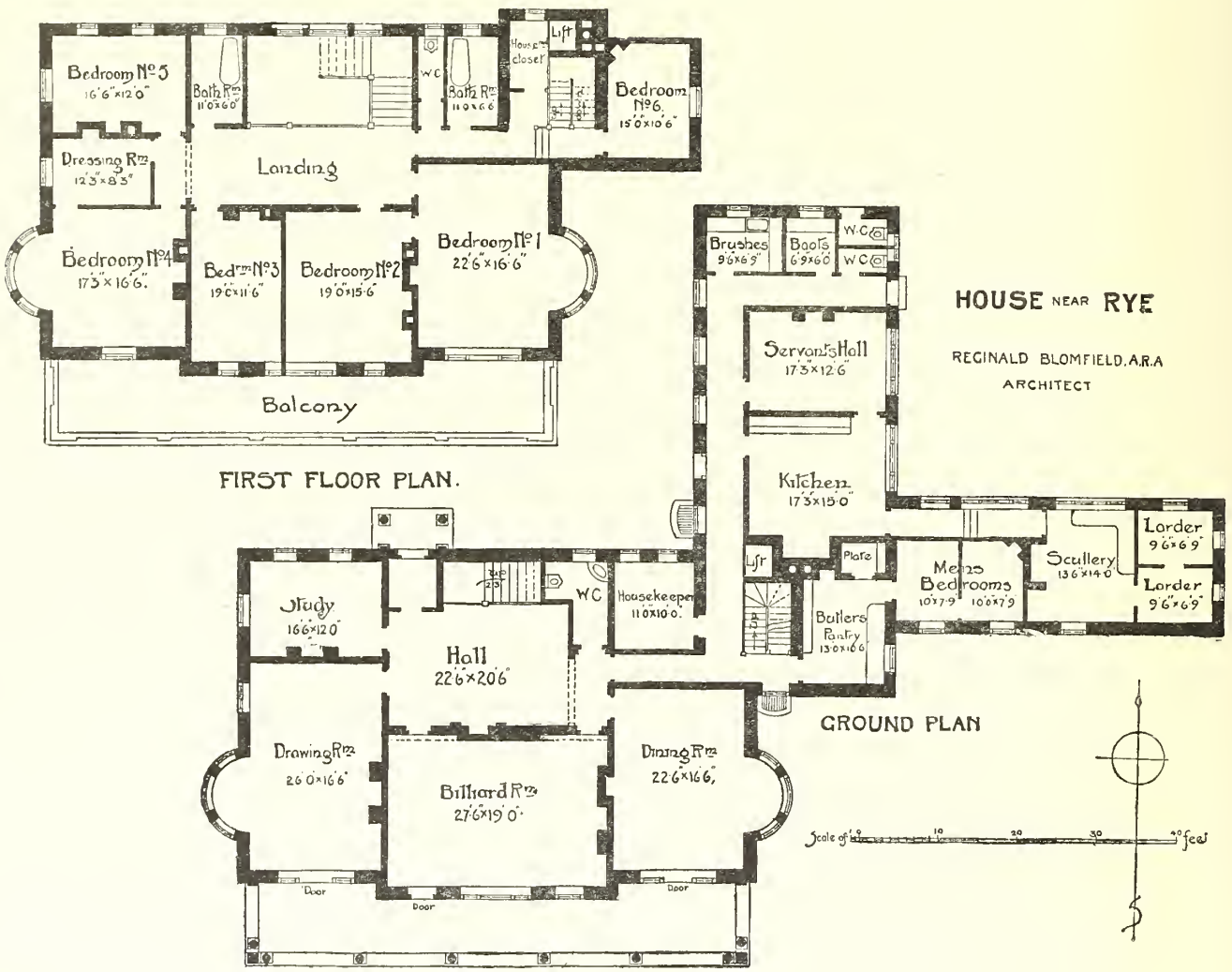


FIG. 47.

house; and in the basement there is also a heating chamber, so that the house is warmed by hot-water radiators as well as by open fires.

On the first floor there are five large bedrooms, besides a smaller room such as would be suitable for a housekeeper or as an isolation room for illness; but there is only one dressing-room, and no definite nursery suite.

The house at Caythorpe, designed by the same architect (Mr. Reginald Blomfield, A.R.A.), is of much were arranged, in full sunlight, the main part of the house being L-shaped so as to take full advantage of the prospect over these and the surrounding country. The fall of the land and its careful terracing is shown in Fig. 47A by a strongly marked section.

On the north side of the house equal skill is shown the arrangement of the entrance drive, providing direct communication with stables and the back entrance, all laid out in direct lines, yet with careful screening

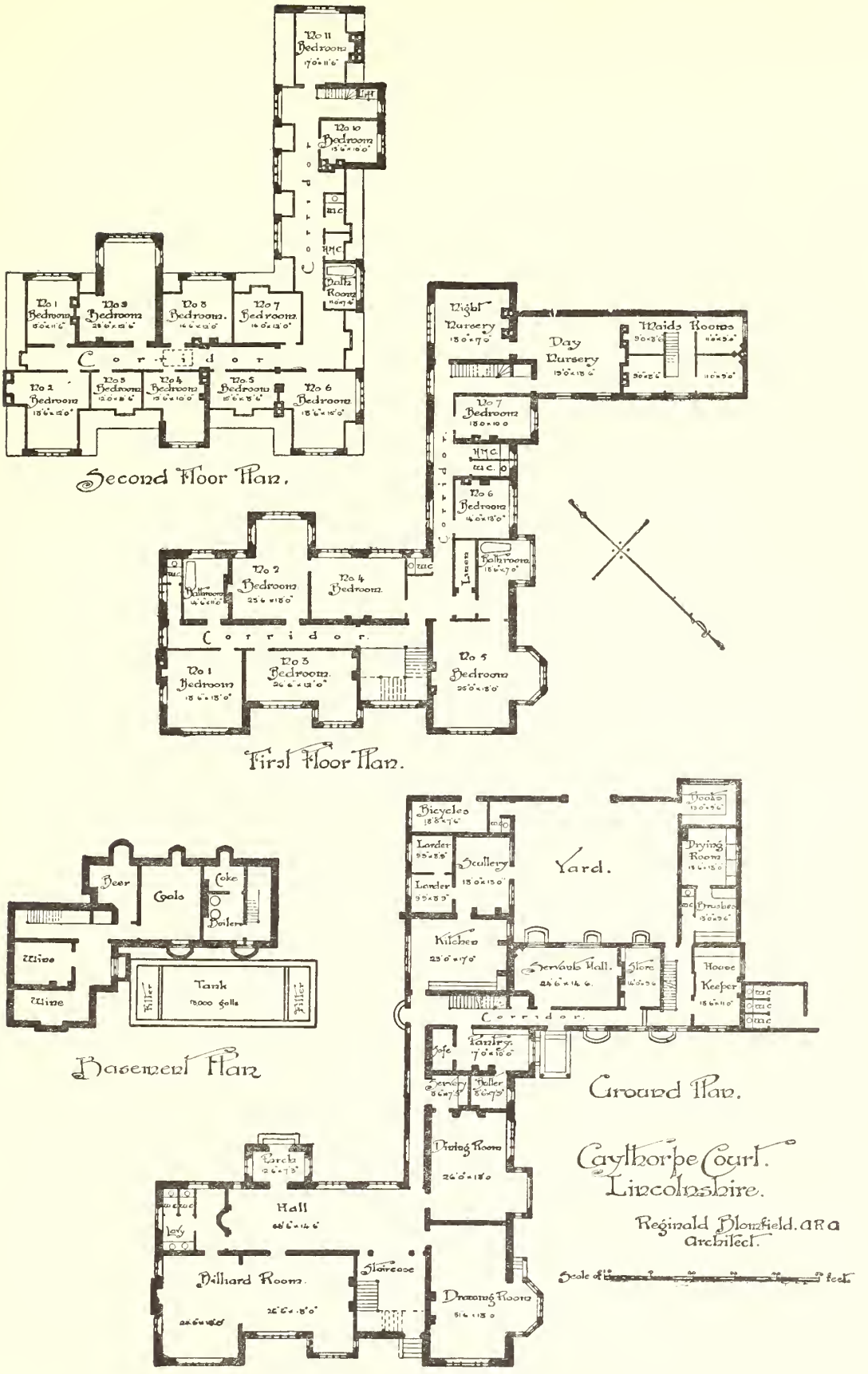

No 11 Bedroom
No 10 Bedroom
Corridor
No 1 Bedroom
No 2 Bedroom
No 3 Bedroom
No 4 Bedroom
No 5 Bedroom
No 6 Bedroom
No 7 Bedroom
No 8 Bedroom
Bath Room
Corridor
Second Floor Plan.
Night Nursery
Day Nursery
Maids Rooms
No 7 Bedroom
No 6 Bedroom
Bathroom
Linen
No 2 Bedroom
No 4 Bedroom
No 1 Bedroom
No 3 Bedroom
No 5 Bedroom
Corridor
First Floor Plan.
Beer
Coals
Coke
Boilers
Wine
Wine
Filter
Tank
18000 Galls
Filter
Basement Plan
Bicycles
Larder
Scullery
Larder
Yard.
Kitchen
Servants Hall.
Store
Corridor
Pantry
Safe
Servery
Butler
Dining Room
Porch
Hall
Lady
Billiard Room.
Staircase
Drawing Room
Ground Plan.
Caythorpe Court.
Lincolnshire.
Reginald Blomfield. ARA
Architect.
Scale of 1/8" 2 feet

FIG. 48.

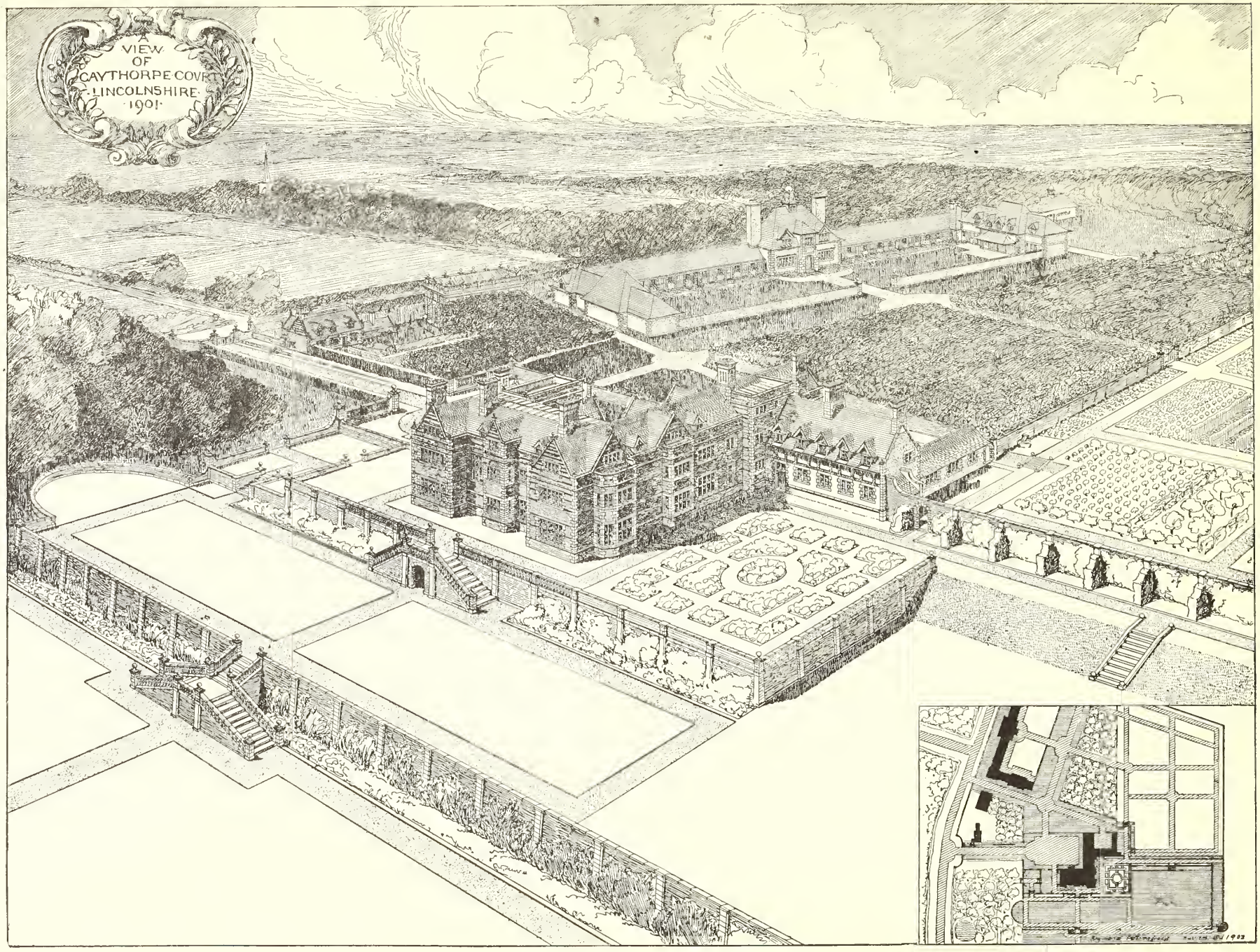


FIG. 49.

where necessary; while a regularly disposed kitchen garden is readily accessible from the servants' quarters, and in full sunlight, adjoining the pleasure garden.

The principal feature of the ground plan (see Fig. 48) is a very large hall, from which the staircase is recessed on the south-west, so that sunlight streams in through the staircase window and lights up the northern hall through an arcade. The effect of "hidden light," as it is called, is always good, and in this case the whole plan of the hall lends itself to its enhancement. The three sitting-rooms are in ideal positions, and from one of them, a combined library and billiard-room, a large cloak-room for gentlemen is entered, with well-lit lavatory and w.c.'s.

Good lighting has throughout the plan been very carefully obtained by means of corridors against external walls, while the servants' quarters have been departmented in a manner which would count much in securing easy management. Thus both kitchen and pantry serve the dining-room with ease; yet the cook's and the butler's departments are each distinct, as is also what may be called the servants' living quarters, consisting of the servants' hall, housekeeper's room, and housekeeper's stores, and linen-room.

From a constructional point of view the great use made of straight walls and the simplicity of the roofing are very noticeable.

There are two back staircases, each of which leads down to a cellar. One cellar is provided with a lift to all floors, and contains the stores for coal, beer, and wine; while the other contains the heating chamber, which would be attended to by one of the outdoor staff of a big establishment. It will be noticed how easily he obtains access from the yard, under a staircase which leads up to a suite of maid-servants' bedrooms on the first floor.

There are several large bedrooms for the family and guests on the first floor, as well as two bathrooms and a complete nursery suite, one of the bath-rooms opening from the principal bedroom to serve as a dressing-room.

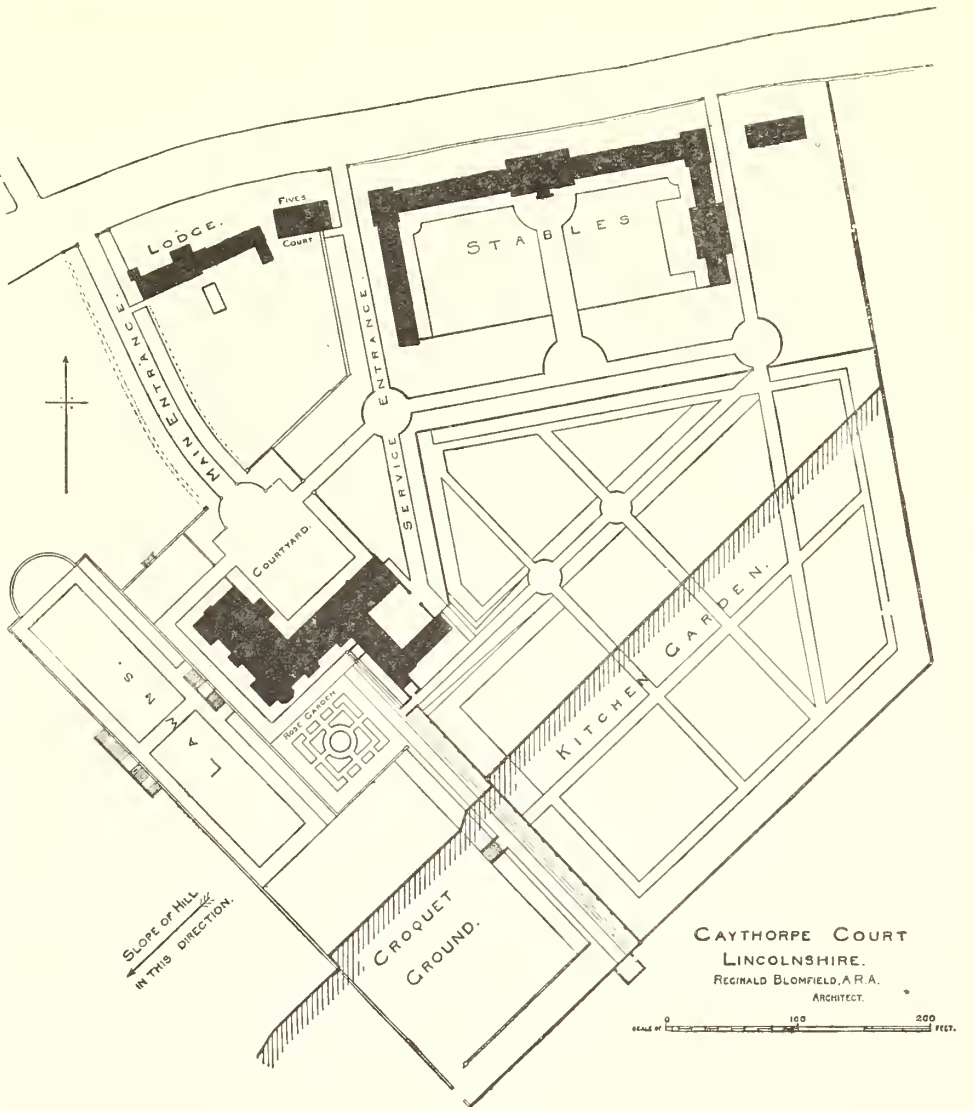


FIG. 47A.

The second floor is reached by the middle staircase only, and is given up to servants' bedrooms and a bathroom.

A general view of this important house, which illustrates well its position in relation to the grounds, is shown in Fig. 49.

"Woodgarth" at Knutsford, designed by Messrs. Worthington & Son, is planned on the same idea, and for much the same aspect as "Caythorpe," though it is on a much smaller scale (see Fig. 50). The most has here been made of comparatively small grounds and greatly restricted views by contriving the drive round a circular pergola on the north, within an angle of the wood, from which it is separated by grass, while there is a screen of roses on the south-east, surrounding a sunken and sun-lit tennis-court, to which it imparts

the needed shade, while a mass of blossom is seen from the house.

In this house the entrance is in the re-entering angle of the L, and an inner hall has to serve the purpose of a drawing-room, for which there is no provision. The kitchen is separated from the house proper by a serving passage large enough to be used as a pantry, and the scullery with its washing copper is again disconnected, though, by means of a covered way, both it and the coal-store and servants' w.c.'s can be easily reached under cover. Minor points, such as the supply of coals from the stable-yard, have been well considered, and the plan is worth a good deal of careful study.

A circular porch gives entrance to an irregular hexagonal hall, from which a study and stairs are reached, as well as the raised platform of a billiard-room at the western end of the house. The dining-room is, as is customary, in the south-east corner, the cloakroom and gentlemen's w.c. adjoining it, while the servants' hall is close to the porch.

"The Tower" at Pangbourne (Fig. 51), designed by Mr. John Belcher, A.R.A., is a house of a somewhat different type, being planned with one long corridor from east to west, which passes along the north side of the main house and the south side of the servants' quarters, thus providing absolutely direct communication, while the two parts are cut off from view of one another by intervening stairs, made possible by differences of level. A similar staircase at the west end of the main corridor screens the cloak-rooms. The billiard-room is on the north-west, with a top light, and the south-west corner of the house is occupied by a suite of business rooms having external as well as internal access. The terrace in front of the drawing and music-rooms, and the enclosed rectangular garden to the east, with its covered verandah, which the dining-room overlooks, are exceptional and beautiful features.

On the first floor a certain amount of departmenting is observable, rooms being arranged in suites in a manner which might, under certain circumstances, be of high value, especially when entertaining important guests, but the total number of bedrooms is not large for so evidently important a house.

Throughout the plans illustrated in this and the previous chapters it will be noticed that the system of separation or departmenting of the various sections has gradually developed. The necessity for this has perhaps not been always definitely recognised by architects, although those who are of the higher rank have at least aimed at it, and have almost always secured it. They seem to have done this instinctively, without actually knowing that they were departmentalising, and the result is so good that it would be most unwise not to emphasise it, in order that others who have not recognised the system may adopt it, for the avoidance of confusion in their plans. It must, in fact, be always borne in mind that a house must be suited to its tenants. A cottage which is worked entirely by the owner, without the assistance of servants, is a self-contained unit which needs no departmentalising other than the usual division into living rooms and bedrooms, and this is generally accomplished by placing the working rooms on the ground floor and the sleeping rooms above. Next comes the small house, in the management of which the mistress takes a considerable part, though she has the assistance of one or two servants. In such a case the kitchen department needs to be cut off from the house proper; and this separation into two distinct departments becomes more and more marked as the house becomes larger, until in the largest type there are practically two houses side by side, the family knowing nothing of the life in the kitchen, and the servants scarcely penetrating into the house itself. The larger houses, too, admit of the introduction of a good many additional conveniences. Rooms are increased in size, and the planning may become more simple and direct. Systems of heating and ventilation may be introduced other than the open fire, and many problems are easily solved which are great difficulties in a smaller residence. Amongst the conveniences added are those of special service arrangements, with butler's rooms, on the ground floor, and the provision of plenty of dressing-rooms and bath-rooms on the upper floors, approximating gradually to the American idea of supplying each bedroom with a separate bathroom, or at anyrate of having fixed wash-stands in the bedrooms, with hot and cold water supplied to them, in place of movable pieces of furniture.

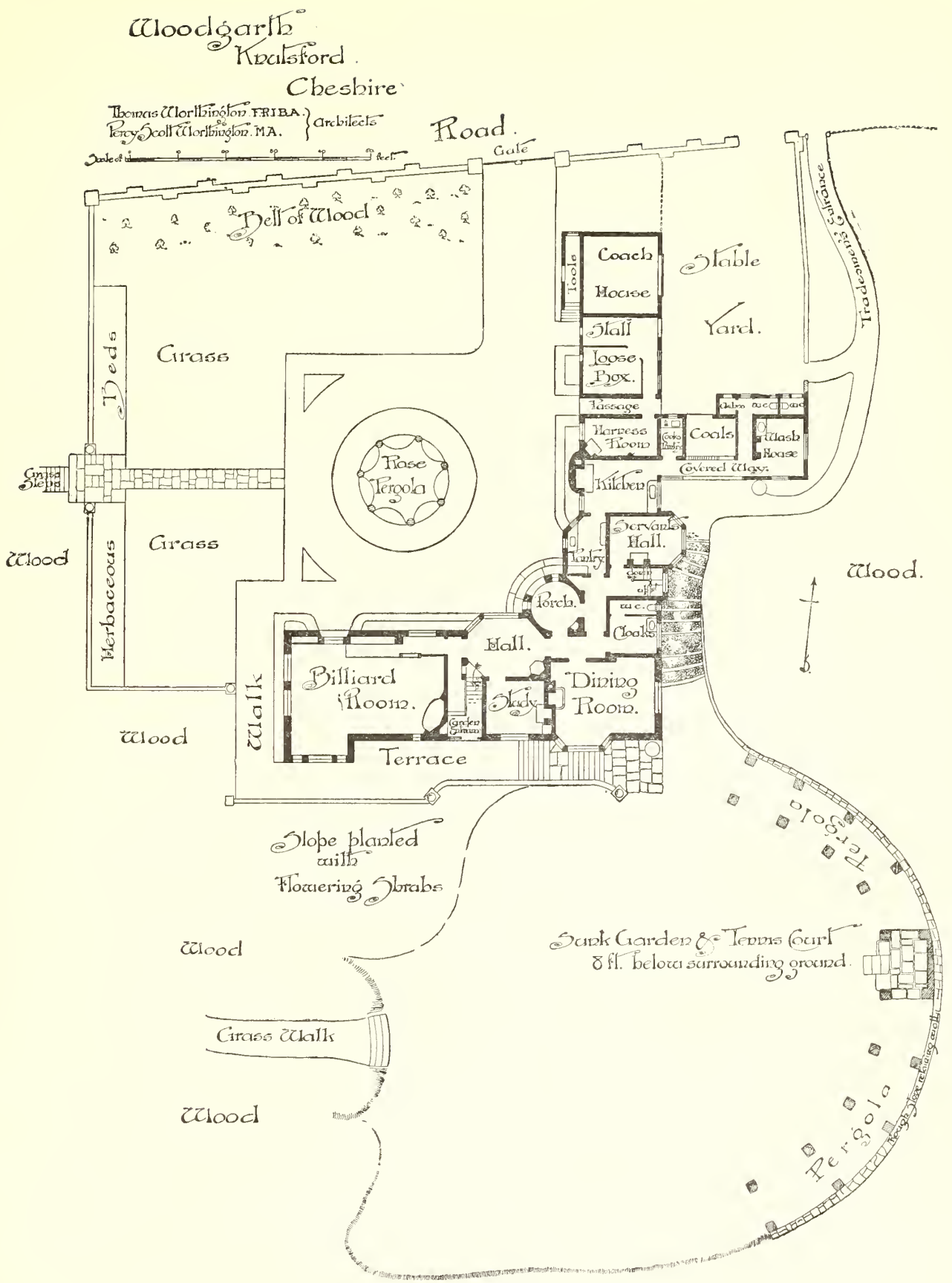

Woodgarth
Knutsford
Cheshire
Thomas Worthington FRIBA.
Percy Scott Worthington MA.
Architects
Road.
Gate
Dell of Wood
Beds
Grass
Grass Steps
Rose Pergola
Herbaceous
Grass
Wood
Wood
Wood
Wood
Wood.
Coach House
Stable Yard.
Tools
Hall
Loose Box.
Passage
Harness Room
Coals
Wash House
Covered Way.
Kitchen
Servants Hall.
Pantry
Porch.
Cloaks
Hall.
Billiard Room.
Study
Dining Room.
Terrace
Walk
Tradesmens Entrance
Slope planted with Flowering Shrubs
Sunk Garden & Tennis Court 8 ft. below surrounding ground.
Grass Walk
Pergola
Pergola

FIG. 50.

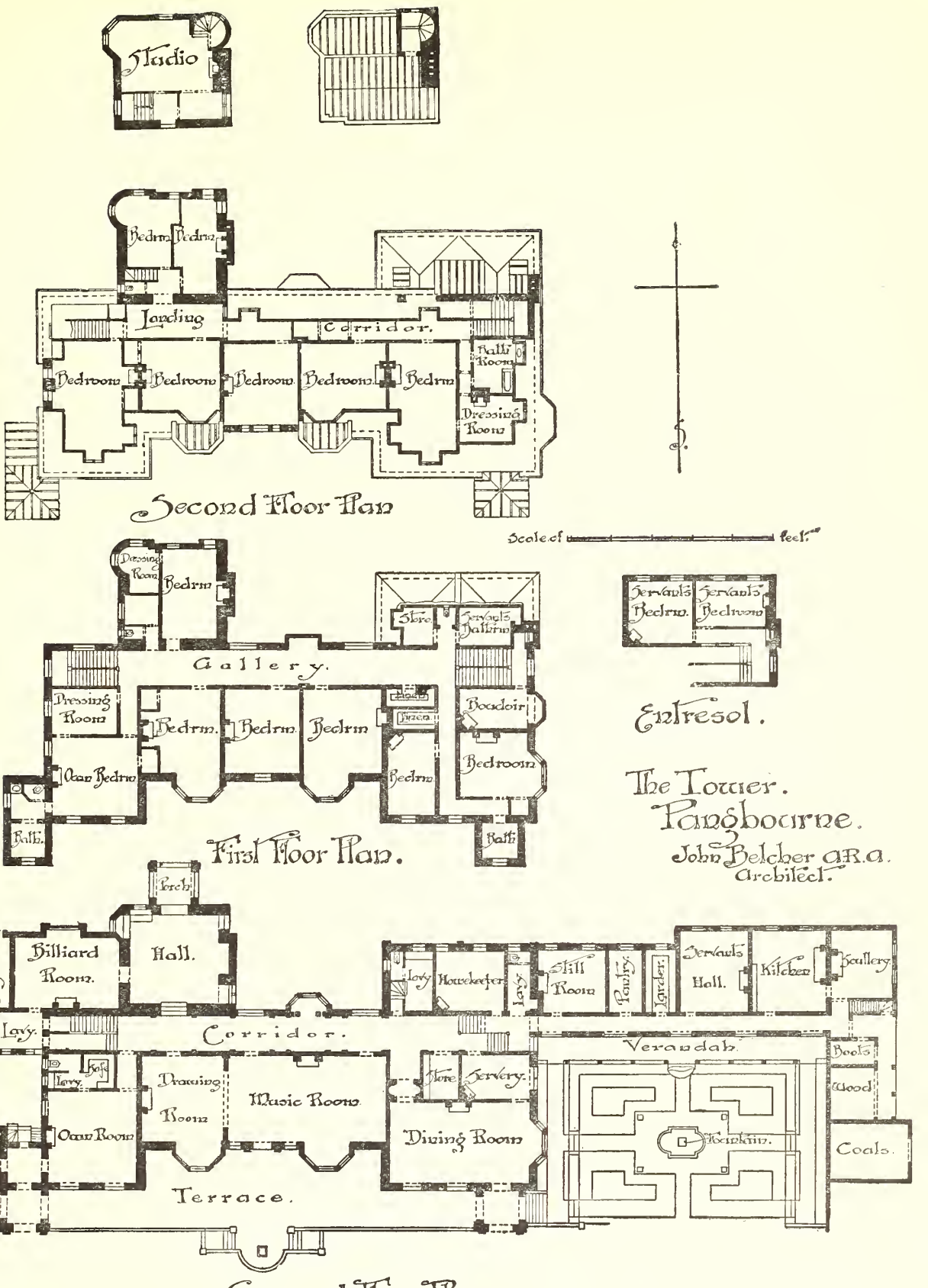

Studio
Bedrm.
Bedrm.
Landing
Corridor.
Bedroom
Bedroom
Bedroom
Bedroom
Bedrm
Bath Room
Dressing Room
Second Floor Plan
Scale of feet.
Dressing Room
Bedrm
Store
Servants Hallrm
Gallery.
Dressing Room
Bedrm.
Bedrm.
Bedrm
Bedroom
Bedrm
Bath
Bath
First Floor Plan.
Servants Bedrm.
Servants Bedroom
Entresol.
The Tower.
Pangbourne.
John Belcher A.R.A.
Architect.
Porch
Billiard Room.
Hall.
Bicycles
Lavy.
Corridor.
Lavy
Housekeeper
Lavy
Still Room
Pantry
Larder
Servants Hall.
Kitchen
Scullery
Lavy.
Boot
Drawing Room
Music Room
Store
Servery
Dining Room
Verandah
Boots
Wood
Coals
Office
Ocan Room
Fountain.
Terrace.
Ground Floor Plan.

FIG. 51.

CHAPTER IV

MINOR POINTS IN HOUSE PLANNING

The last three chapters have dealt with the principal requirements of house plans—their aspects, the position and interrelation of the various rooms, and, in the case of the larger houses, the proper separation of the various departments, together with such essentials as the provision of ample sunlight and the possibility of constructing, and especially of roofing, the house with ease. Still, there are many little points to which scant or no attention has yet been given, which, nevertheless, are of real importance.

Light.—Not only is it desirable to plan so that direct sunlight shall be admitted, at some time of the day, to as great a part of a house as possible, but ample light must be provided to all parts. The general rule is, that the clear area of the glass in the windows of a room must be at least equal to one-tenth of the floor area, while every landing, passage, or staircase must have one window opening directly to the open air; but this rule is for the minimum and not for the maximum, and the more light in excess of this requirement the better. Dark corners and passages are not only awkward, but great harbourers of dirt, and the unsuspected cause of much illness; while light is the great germ killer and exposer of all that should not be in a house.

Consequently, not only should there be plenty of windows to the rooms of a house, but to its halls, passages, staircases, store cupboards, and most particularly to the w.c.'s and the larders,—and in all cases the light should be direct from the open, and not "borrowed" or obtained across another room.

The positions which the windows occupy also greatly affect their value. A window at the end of a long passage is, for instance, of much less use than one in its side wall, about the middle of its length; the effect of walking towards a window being, that anyone coming in the opposite direction is seen in shadow, while if you are walking away from the window you are yourself obstructing the light to all the rest of the passage.

In sitting-rooms the windows should be placed, so far as is possible, to give side light to any tables or seats used for work or reading, and to the piano; and in the kitchen to give a direct light to the working table and a side light to the range, while direct light over the sink is most useful in sculleries and pantries. In bedrooms light is needed to shine directly upon the person when standing before the looking-glass, the best arrangement being, possibly, the provision of two windows in the same wall, with sufficient space between for the dressing-table. A small window, somewhat high up, is sometimes useful beside the bed to give light for reading if the room is occupied by an invalid; and similar supplementary windows may well be introduced into sitting-rooms, to light ingle-nooks or the position which a desk or piano would occupy. To staircases and halls often a top light is the best—that is, the most diffused; but it is always difficult to clean, and is often used by the unskilful planner as an easy solution of an awkward problem which could be better solved in some other way.

Artificial Light needs just as careful consideration as that from windows. Whether gas or electricity be used, the lights have to be placed where they will best do their work; and in the case of gas, where the taps are easily within reach, and the flame in such a position that light curtains are not likely to be thrown or blown across it, and out of direct and sudden draught. It is also advisable to avoid positions from which the shadows of occupants of the room will be thrown upon the window blinds, particularly in bedrooms, bath-rooms, and w.c.'s.

Possibly a suspended centre light is best in a dining-room, as it avoids shadows upon the dining-table; but in the hall and other sitting-rooms it is possible to exercise discretion to a large extent, remembering that diffused is more pleasant than concentrated lighting, while the best artistic effects are to be obtained when the source of light is invisible. Bracket lights or standards, it will be borne in mind, are the most suitable for incandescent gas burners, causing less destruction of mantles than swinging or other hanging lights.

In bedrooms the best position for lights is just above and in front of the looking-glass—preferably suspended electric lights; but this position is a difficult one in which to put gas without risk of setting the window curtains on fire.

Proper lighting to desks and piano, to persons reading in front of the fire, to the kitchen range and table, and in the passages, so as to have no dark corners, are all matters requiring careful thought, preferably upon the spot; but many architects will denote the positions which lights should occupy by some sign, such as ⊠, printed in red upon the plans.

Ventilation and Heating, cognate subjects, to be dealt with fully in a later Volume of this book, receive much less attention in the ordinary small and middle-class house than they properly deserve. When fires are alight in the winter-time, very efficient outlet

ventilation are provided by their flues, but if equally effective inlets are not carefully arranged, the air to supply them is drawn in from every crevice in the windows and from beneath the door, causing sharp draughts of cold air, especially along the floor between door and fireplace. This is now generally provided against in large houses by a supplemental system of heating and ventilating by means of warmed air; but in small houses no provision whatever is made. Undoubtedly the best thing is to use a warm-air grate, whereby the incoming air is warmed before admission, but this is costly, and so usually the most that can be done is to provide an inlet at a high level through one of the outside walls, or to construct the window—if of the double-hung sash type—with a deep inner bead on the sill, so that the lower sash may be raised an inch or so and air admitted between the sashes.

Fireplaces ought to be so placed as to throw radiant heat into all parts of a room, but this theoretical requirement is rarely obtainable, an angle fireplace alone succeeding fully in doing this. In any case the position should be one from which heat will radiate directly over a large area, without the fire being too close to, say, a dining-table to be comfortable. It should also be screened from the door so as to avoid direct draught, this being frequently done by forming a recessed ingle-nook.

The hall and staircase of a small house are always difficult to heat, yet if unheated they are exceedingly uncomfortable in cold weather. If a fireplace can be contrived, the hall may, on the other hand, be a great source of comfort, and the whole house be kept warm; while, if space be lacking for this, it is often possible to introduce a small hot-water radiator supplied from the hot-water circulating system which most houses now possess.

Another useful economy of heat frequently wasted is to place the hot-water cylinder of the circulating system in a linen cupboard. This involves careful planning, that the cupboard may be in its right position in the house and the flow and return pipes between cylinder and boiler short and direct; but this can frequently be managed with little difficulty, and the advantage gained is considerable. A heated linen cupboard, such as is obtained in this way, should, however, have inlet and outlet ventilators for the admission of cold air at the bottom and the removal of heated air at the top, and the hot-water cylinder should be near the inlet, so that a current of warm air is constantly passing over and amongst the linen, drying it and carrying away any moisture in a state of evaporation. If this is not done the linen will be merely heated and not dried, and may even turn mouldy if left thus for any length of time. Rails as well as shelves should be provided in such a cupboard for more effectual drying.

Windows and Doors.—The comfort of an apartment depends to a very large extent upon the relative positions of doors and windows, both in regard to one another, to the fireplace, and to the necessary furniture. Primarily, windows are needed for light and view—especially for the admission of sunlight—doors for ingress, and fireplaces for warmth; but secondarily, all act as ventilators, and, if not very carefully placed, cross draughts will result where their absence is the chief essential, and other inconveniences will follow.

It being difficult to avoid all draught between door and window, it is advisable, where possible, that this should traverse as short a space of the room as possible, while the necessary current of air from either or both to the fireplace outlet ventilator should be so broken as to flow in a diffused manner, imperceptible, rather than in definite currents either along the floor or elsewhere. Thus doors and windows may be opposite one another so long as only a comparatively small portion of the room is traversed between them; but neither should be opposite a fireplace, which, as already said, is best screened by being placed in an ingle, or by building a permanent screen wall, or at least by so opening the door as to protect it.

In a *Dining-room*, which in most houses is used as the general living room, this should be carefully observed, the fireplace being either placed in a corner or recessed so that the heat shall not strike too fiercely upon the backs of persons seated at the table; and any such ingle recess should have, if possible, one small window, well made that it may not admit draught when closed, and placed somewhat high on one side, to give light to any person seated reading or working in the recess. The door, also, should be near one corner of the room, opening inwards in such a way as to screen the room without impinging on the table or any of the chairs round it, and giving direct access from hall or passage to a dumb-waiter or dinner-waggon placed just inside the room. The window is best at the side of the room, throwing light across the table rather than along it.

In *Drawing-room* or *Study* the principal need, again, is protection against draught, combined with ample lighting and warmth; and the light is particularly needed to the piano in the one case, and to the writing-table and book-shelves in the other, preferably falling from the left-hand side in both instances. The piano, indeed, needs careful placing, in a spot which is quite free from draught, and as far as possible of equal temperature, while it should permit any singer, standing behind the pianist, to sing into the room—difficult conditions to reconcile, especially with an upright piano, yet all the more necessary to consider when the room is planned.

The *Kitchen* requires its fireplace particularly well screened from the door, and well lit from the left hand, while plenty of light should also fall on the dresser, which is best placed in a recess opposite the window. In small kitchens particularly a considerable amount of skill is necessary to plan them so that they are not

mere draughty passages between the entrance hall and the scullery and back door on the one hand, or oppressively unhealthy furnace houses on the other.

Whenever space permits the *Hall* should be screened from the entrance door by a vestibule, the entrance and vestibule doors opening inwards and all others outwards from it. Space has to be provided in it for a hat and umbrella-stand, out of the direct passage, and in almost all small houses for perambulator or bicycle also, unless there be a separate bicycle-room.

The *Staircase*, while it should be particularly well lit, warmed, and ventilated, being the principal "lung" of a house, is frequently the part most neglected in all these respects. A hall, fire, stove, or radiator will warm the staircase, and usually plenty of inlet ventilation is provided through the front door; but a low window which can be opened at will is preferable, especially if combined with another to serve as an outlet on the top landing or on the roof—though top lights are difficult to clean, and so are apt in course of time to become lights in name only.

Though "winders" have occasionally to be used in small houses where extreme economy of space is requisite, they should be avoided if possible, and the stairs be in straight flights of not less than three nor more than thirteen, with square landings. Comfortable going is generally attained if the rise multiplied by the length of tread (both in inches) equals 66 or nearly so; but the rise should not be less than $5\frac{1}{2}$ nor more than $7\frac{1}{2}$ inches.

Bedrooms require that places should be provided for the bed, dressing-table, wash-stand, and wardrobe or chest of drawers, and these are obtained successfully or otherwise almost entirely by the positions selected for windows, doors, and fireplaces. Generally speaking, it is advisable that door and window should occur towards the same end of the room, the bed and the fireplace being screened by the door as it opens; but a second window, of small size, providing light to the head of the bed, is often of great use. On the other hand, one bedroom should be arranged in every house for a draught to pass right through it, this being essential in many cases of infectious illness—though often obtainable, in a room not specially planned for the purpose, by putting the bed temporarily between door and window. Two windows, with the dressing-table between them, are best for lighting that piece of furniture, and wall space against which to place the wash-stand should be provided, well lit, yet away from prying eyes.

Bathrooms should have their window-sills somewhat high above the floor, and the glass should be "obscured"; but if window and bath be relatively carefully placed, nothing which takes place within can be seen externally. It is well for door and window to be opposite one another, to give a through draught when required; but a fireplace, if provided, should be sheltered, as it would be mostly needed for invalids and young children after undergoing a warm bath at bedtime.

Of the smaller offices of a house, it is only necessary to remark that all larders, cupboards, w.c.'s, cistern rooms, and coal cellars should have ample window area, and the means of providing a through current of air between door and window—this being most particularly necessary in any cellar in which the gas meter may be placed. A dark cupboard in a bedroom, too, though often much liked by the housewife, is liable to become a mere well of stagnant air, often damp from the presence of unaired clothing.

In the matter of construction the coal store is, or should be, peculiar in having a sloping floor, preferably dished, falling towards the front, where there should be a low screen wall with a small sliding door in it, toward which the coal naturally gravitates and from which it can be removed without causing dust or inconvenience. Such an arrangement, the floor being

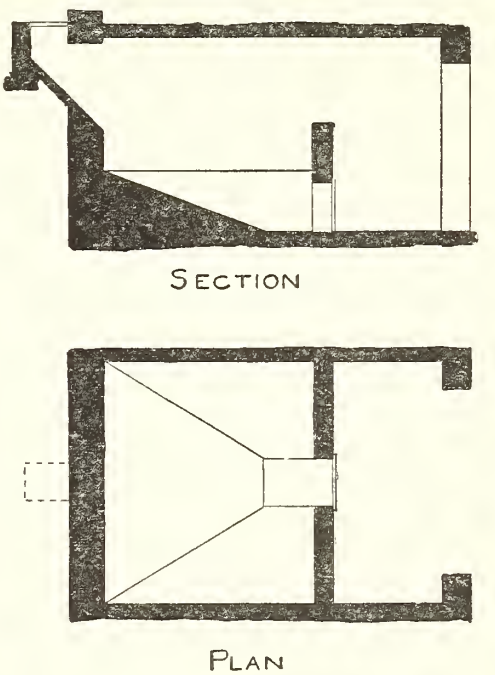


FIG. 52.

of concrete, cement rendered, is shown in Fig. 52, but something of a similar nature can be easily constructed of timber on an ordinary level floor.

LOCAL BYE-LAWS and BUILDING REGULATIONS affect planning, both horizontal and vertical, and construction also, to a very large extent. They vary so much, however, that it is impossible to do more than refer to them, and to advise strict compliance with them in all cases, however unreasonable they often seem, and are, even though in doing so some primary considerations have to give way. They can be enforced, and the architect who tries to evade them, even though by so doing he may produce a better house, is likely to

bring much trouble upon his client and discredit to himself. Consequently, when planning a building in a new district, the very first thing to do is to obtain a copy of all local building regulations, and to adhere to them.

It may, however, be possible to give some slight idea of the principal provisions, and of the difficulties which are consequently to be met with in several country districts. There is, for instance, usually a regulation to the effect that walls shall be built upon footings, and these upon concrete of a certain specified thickness. Although it is better construction and cheaper also to increase the thickness of the concrete and omit the footings, this is not permitted, and the footings must go in. Here and there a local surveyor is met with who will understand the logic of providing something better than the Bye-Laws admit, but the majority insist upon absolute compliance.

The thicknesses of the walls, both externally and internally, are generally specified, and the party walls in the case of a row of two or more cottages have almost invariably to be carried through the roof, and to project above it to a height of some 15 inches. In some districts it is permissible to merely bring this party wall up to the under side of the roof covering, while in some few other districts a pair of houses, but not more, may be erected without carrying up a party wall beyond the ceiling level.

It will generally be found that the whole site has to be covered with 6 inches of concrete, and in some few districts the quality of the concrete is stipulated. This provision will be found to be applied even in places where there is a solid rock or chalk foundation, although it is there entirely unnecessary.

The external walls are, even in rural districts, frequently obliged to be built in brick, stone, or other incombustible material, and this forbids the use of half-timber work, sanctioned though it has been by many centuries of use, and rarely involving serious risk, at any rate in detached dwellings.

These are perhaps the most vexatious provisions, and those which most seriously increase the cost of building small cottages in country places. Besides these there are others which regulate the sizes of windows in relation to rooms, and stipulate for their being placed sufficiently high for purposes of ventilation. Proper damp courses and the proper ventilation of space under floors are very rightly insisted upon, and so, too, is it always compulsory that woodwork should be kept at a sufficient distance from all flues to secure safety from fire, while flues may not be carried at too sharp an angle or too nearly horizontal without the provision of sweeping doors.

It may be said that the general idea of the Model Bye-Laws was to secure stable building and security against fire with the least possible expense; but they were devised for certain districts near London, and when applied to other parts of the country without proper consideration of the local requirements they have not always proved satisfactory.

PART III

THE CONSTRUCTION OF A BUILDING'S SHELL

(*Contributed by H. V. Margary*)

CHAPTER I

SOILS AND FOUNDATIONS

Before the foundation of any building can be designed the nature of the soil on the site must be inquired into. Soils are practically infinite in their variety, both with regard to their composition and their weight-resisting properties; but those more commonly met with are rock, chalk, clay, gravel, sand, silt, or quicksand, and various combinations of these.

Soils may be classified according to their behaviour under the influence of heavy loads, under the following heads:—

1. Practically Incompressible Soils.
2. Compressible Soils.
3. Soils which escape Laterally.

1. Practically Incompressible Soils include those which can only be worked by a pick or by blasting, such as *rocks*, *stony earth*, *hard compact clay*, *etc.*, which enable building to be commenced directly upon them.

2. Compressible Soils comprise such soft soils as ordinary *yellow* and *blue clay*, *common earth*, *marshy soils*, *etc.*, which, when built upon, require wide artificial rafts or "spread foundations" under the walls to distribute the pressure.

3. Soils which escape Laterally are such as *sand*, *loose gravel*, and *silt*, which would squeeze out from under heavy buildings unless some means were taken to confine or consolidate it to a given area.

Tables exhibiting the safe bearing powers of various kinds of soil have been compiled by various authorities, but these are of very little use in practice owing to the enormous variations in bearing powers of soils under varying conditions. A very satisfactory way of obtaining information concerning the nature of the soil upon which it is desired to build is to inquire among builders who have erected buildings on adjoining lots; but even this is not always satisfactory, as soils will vary within a comparatively short distance, particularly in the manner in which they overlie one another.

Boring Test for Soil.—If no reliable information can be found concerning the soil, borings should be made at intervals across the site, and if the samples brought to the surface by this means indicate either a dangerous subsoil or a tilt in the strata, tests of the bearing capacity should be taken in the following manner:—

Bearing Test for Soil.—Excavate a trench and level the bottom at the depth at which it is proposed to form the foundation, and lay down four blocks of a definite area in square feet. On top of these build a strong platform and drive a stake into the ground alongside one edge, marking on it the top level of the platform. Gradually load up the platform with bricks, pig iron or other suitable material, and note when the platform begins to sink away from the mark on the stake. The load is measured and the ultimate resistance per square foot is determined and divided by a factor of safety varying from 10 to 25, according to the nature of the soil.

Before any important building is commenced the bearing capacity of the soil should be tested, and the larger the scale of the experiment the greater—as a rule—is the result thereof. A convenient size for the platform is 3 by 3 feet, or 9 square feet in area, as it corresponds with the bearing width of an ordinary wall, and is easily loaded and calculated. If the four angle blocks are made 6 by 6 inches, these have a total bearing surface of one square foot; and thus it comes about that the total load on the platform is the load per square foot borne by the soil.

The term "foundation" as applied to a wall having footings is, throughout this work, taken to mean the artificially formed support on which the footings of the

wall rest. Where such foundations are used the term "foundation-bed" is employed to distinguish the surface upon which the foundation rests.

When designing foundations the following principles, which are applicable to all cases and all materials, should be strictly adhered to:—

1. They should be proportioned so as to ensure uniform settlement.

2. They should be perpendicular to the pressure brought to bear upon them.

3. They should be sufficiently large to resist that pressure.

4. They should be of some durable material.

1. Uniformity of Settlement.—No attempt need be made in designing footings to prevent settlement as this is not possible, but the footings should be so proportioned that the amount of settlement should be reduced to a mininum, and, what is more important, every precaution should be taken that the settlement may be uniform. To achieve this desirable object the causes of unequal settlement must be understood.

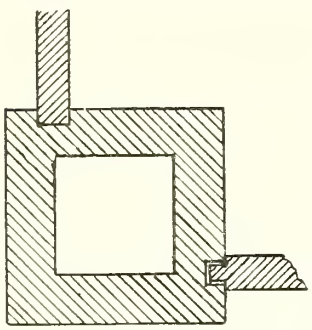


Fig. 53.

Unequal Loading of Foundations.—The most frequent cause of unequal settlement is due to the unequal loading of the foundations. For instance, if a tower is built on to a lower building its tendency is to settle to a greater extent than the less heavy portion of the building, and unsightly cracks appear on the face of the structure. To prevent this the foundation under the tower should be large enough to produce the same pressure per square inch as that under the lower walls. But even this is not always satisfactory, and a better plan in such a case is to avoid bonding the two portions of the building, preferably disconnecting them by means of a slip joint as shown in Fig. 53. Another frequent cause of unequal settlement is illustrated at A in Fig. 54, where it will be seen that the weight of the structure is brought down the piers upon the ends of the foundations, while the upward resistance of the foundation-bed causes the fracture here shown. The remedy for this is to isolate the foundation for each pier as shown at B in the same Figure. In town sites it is frequently impossible to build footings on both sides of walls next to walls of surrounding properties, when the centre of gravity of the wall falls away from the centre of resistance of the foundation-bed as in Fig. 55, with the result that the walls tend to tilt outwards, as shown by the dotted lines. This tendency cannot very well be prevented, but every precaution should be taken to prevent failure by anchoring the walls together and stepping the footing to a steep angle—never less than 60 degrees. An additional "heel" of concrete, as shown hatched in the illustration, is a great safeguard against any tendency to overturn and fracture. The modern method of overcoming this difficulty is by the use of cantilever foundations, as explained in Part II. of Volume IV.

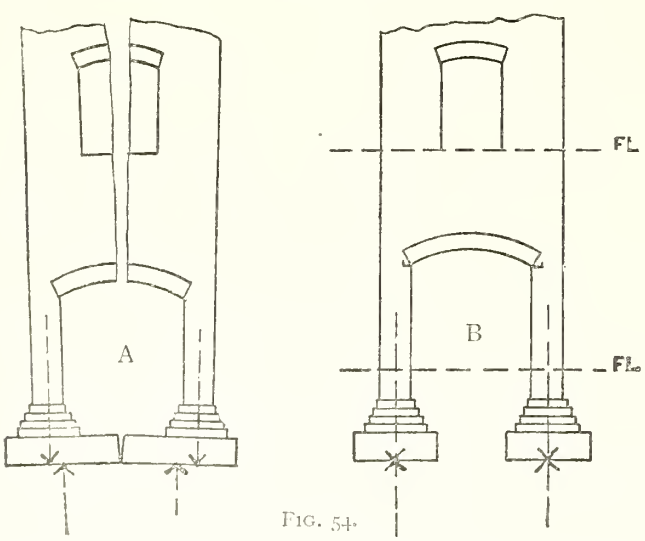


Fig. 54.

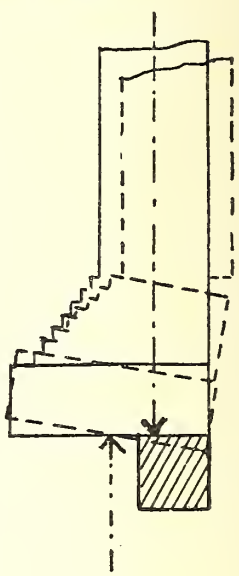


Fig. 55.

Differing Soils.—Failure is often caused by foundations being placed upon soils with different bearing capacity, such as rock and soft soil. If the soft portion is small in extent it may be excavated and the fissure in the rock filled up solid with cement concrete, or it may be spanned by an arch (as Fig. 56), a girder, or a concrete lintel, as in Fig. 56; but if it is very large it is better to connect the portion of the structure by means of a slip joint similar to that shown in Fig. 53, and to proportion its foundation to the bearing capacity of the soft soil.

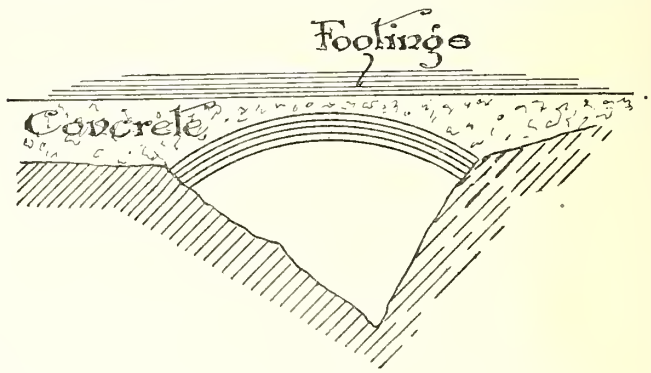


Fig. 56.

2. Direction of Pressure on Foundations.—The

foundations of walls which are only influenced by vertical loads should be horizontal, while the foundation to walls subject to pressures from arches or retained earth should be placed perpendicularly to the resultant oblique pressure in order to prevent the foundations from sliding on their beds. This fact, though obvious, is one which is frequently overlooked in ordinary building works, though it is well recognised by engineers.

3. Size of Foundations.—The foundations should, of course, be of such a size that the load brought upon the foundation-bed per unit of its area may not be greater than what it will safely bear. It is also necessary to apply this principle to the footings of walls, which should be proportioned to the bearing capacity of the material of which the foundations are composed.

4. Durability of Foundations.—Both the foundations and the foundation-beds should be of some material which is of an unalterable nature; that is to say, such as will not decay or disintegrate on prolonged exposure to the atmosphere.

Frost is one of the greatest enemies of foundations, which should be sufficiently deep to be beyond its action,—about 3 feet is considered sufficient in England except for clay soils, which are frequently split up by fissures both during frost and in times of extreme heat and drought. A depth of 4 feet is, however, usually considered to be sufficient even with such a soil.

Types of Foundations

The types of foundation in general use may be classified roughly under the following heads:—

1. Natural Foundations.
2. Artificial Foundations.

1. Natural Foundation is the name applied to such as are formed on the soil itself, and it is applicable when the soil is practically incompressible.

If the site be fairly level it is only necessary to make it thoroughly so, all loose and decayed portions being cut away and filled up with cement concrete. Sometimes fissures occur which, if not too deep, must be filled up with concrete or spanned by an arch as shown in Fig. 56.

If the site is on a slope or in a hollow the loose and decayed portions are cut away and a series of blasts made where the walls are designed to come. The holes formed thereby are filled with concrete, which is then benched up into level steps, upon which the walls are raised. The object of the blasting is to roughen the surface and thus prevent the concrete from sliding. If the soil is likely to be shaken by blasting, then the soil itself must be cut into steps as shown in Fig. 57. A drain must always be cut from the lowest point in the *benching*, to prevent the foundation from becoming water-logged.

When the foundation is benched the walls must be brought up level with large stones with fine bed joists, as at A, Fig. 57, otherwise the settlement of the more

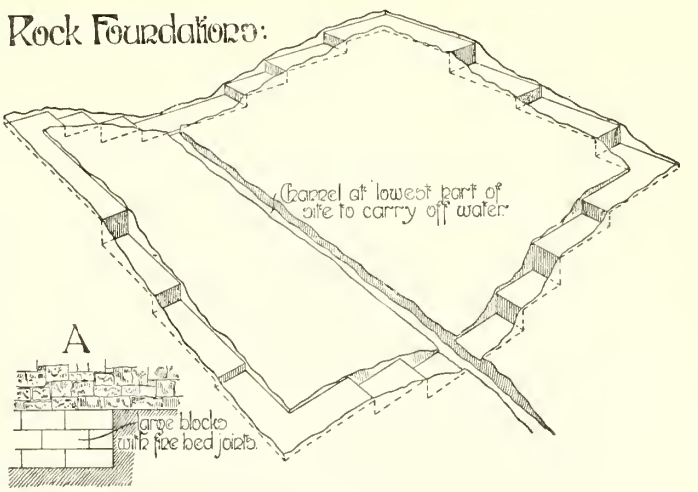


Fig. 57.

numerous joists in the deeper trenches will cause unsightly cracks to appear in the superstructure.

2. Artificial Foundation is the term applied to any artificially formed support for a building, and may be classified as—

1. Spread Foundation; 2. Pile Foundation; and 3. Pier Foundation.

Spread Foundations is the name given to foundations used for buildings upon *compressible soil*. These, consequently, require to extend considerably on each side of the walls, so as to reduce the load per square inch to that which will be safely borne by such soils. Foundations of this class are formed of concrete or large stones and sometimes of wood.

Concrete Foundations.—For small buildings on comparatively firm ground concrete foundations are almost invariably used. For unimportant work the depth or width is rarely calculated, the width being simply made wide enough on each side of the footing to give a man foot-room to work in, and the depth is made at least equal to the thickness of the wall. The footings are usually stepped out to the width of the wall on each side.

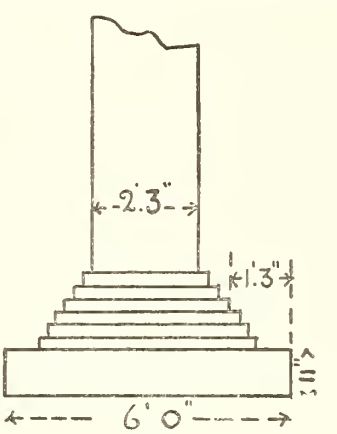


Fig. 58.

Calculation of Width of Concrete.—In important works the load brought upon the foundations must first be determined, and the concrete must be wide enough to reduce the load per square foot of foundation-bed to that which it will safely bear. This may be

illustrated by the following example: Suppose that a 3-brick wall (Fig. 58), which with the usual footings weighs 9 tons per foot run, is to be supported by a concrete foundation upon a soft clay soil which will safely bear $1\frac{1}{2}$ ton per square foot. What width of concrete will be required?

Consider one foot of the wall only, the weight of which is 9 tons. Then—

$$\text{Width of concrete} = \frac{\text{Total load}}{\text{Safe resistance of soil}}$$
$$= \frac{9}{1.5} \text{ feet}$$
$$= 6 \text{ feet.}$$

The Depth of Concrete is calculated by regarding the concrete as an inverted cantilever whose length is taken as half the width of the projecting portion of the footings *plus* the projection of the concrete beyond the footings,—in this case 1 ft. 3 ins., as shown in Fig. 58. The load upon this cantilever is $1\frac{1}{2}$ ton per foot run. The formula for calculating such a cantilever, as obtained by equating the bending moment with the moment of resistance, is

$$\frac{Wl}{2} = \frac{Cbd^2}{6}$$

$$\text{Whence } d = \sqrt{\frac{6 \times W \times l}{2 \times C \times b}}$$

Where W = *ultimate* total load on cantilever, in cwts.
,, l = length of cantilever, in *inches*.
,, b = breadth of cantilever, in *inches*.
,, d = depth of cantilever, in *inches*, and
,, C = a constant for the particular material, called the coefficient of rupture, in cwts.

The value of C is about 8 cwts. for Portland cement concrete; but if, as is more usual, W be taken to represent the actual load (in this case $1\frac{1}{2}$ tons per foot run for a length of 1 ft. 3 ins., or a total of $37\frac{1}{2}$ tons) and not the ultimate load, the value of C is 1 cwt. The equation, in the case exemplified, thus becomes

$$= \sqrt{\frac{6 \times 37\frac{1}{2} \times 15}{2 \times 1 \times 12}}$$
$$= \sqrt{\frac{5625}{4}}$$
= nearly 12 inches.

It is customary where very wide foundations are necessary to bed rolled steel joists or rails in the concrete, but on this subject more information will be found in Volume IV.

A rough-and-ready rule for finding the depth of concrete foundations is shown in Fig. 59. Having found the width by calculation, draw lines at 45 degrees to the horizontal from the points where the faces of the wall cut the uppermost course of footings, and where the line cuts the line representing the width of the concrete indicate the depth thereof.

This rule is fairly satisfactory for thin walls on firm soil, but fails when applied to large walls, especially when on soft soil; but it gives a greater depth than that found by calculation for thoroughly good Portland cement concrete, for it was devised for weak lime concrete.

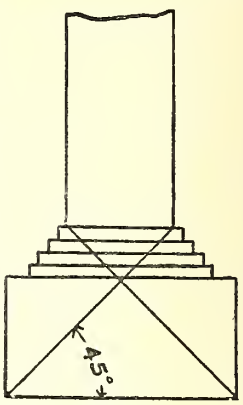


Fig. 59.

Isolated Piers. — When a building is supported upon isolated piers the footings should be stepped out until they meet, and should rest upon a continuous concrete foundation as in Fig. 60.

Inverted Arches. — Where there is not sufficient depth for the above method of supporting piers, inverted arches should be formed from pier to pier as shown in Fig. 61. So as to distribute the pressure along the foundations, care should always be taken to give the end pier sufficient abutment or to tie it in

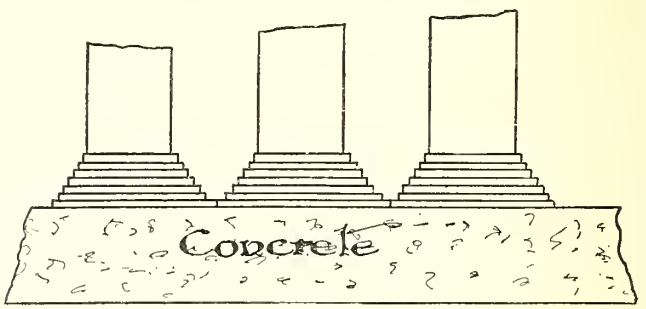


Fig. 60.

with iron tie rods, otherwise it will thrust outward as shown by the dotted lines.

The strength of such an arrangement, as shown in Fig. 62, depends in great measure upon the strength

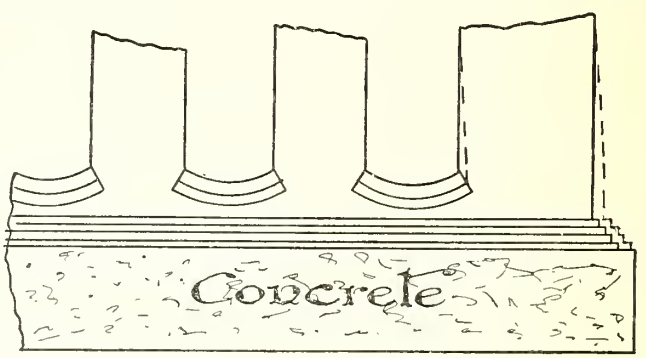


Fig. 61.

of the skewbacks. If these are made too small there is a tendency for the piers to slip past the arches, as shown by the broken line.

A good practice is to form the skewbacks of a single block of granite, but where it is not possible to obtain

the stone in one piece two pieces may be used jointed in the manner shown in Fig. 63. It adds considerably

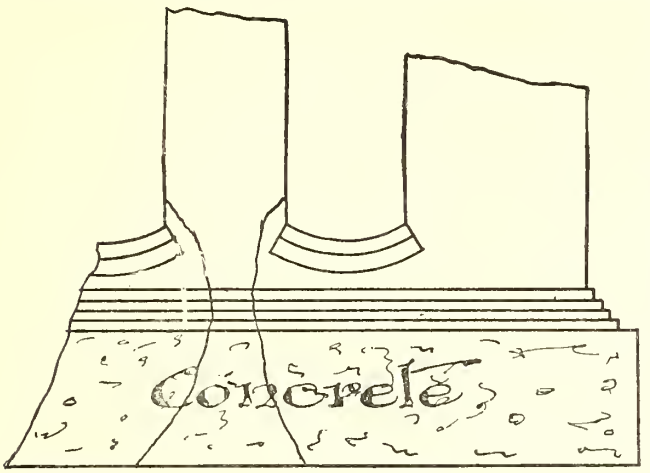


Fig. 62.

to the strength of piers to build large horizontal slabs of stone into them at intervals.

Plank Foundations.—When the bearing capacity of a soil is very small, concrete becomes an unsuitable material for foundations on account of its comparatively small power to resist a transverse stress. In such a case planks of oak, beech, pitchpine, creosoted

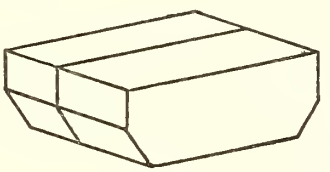


Fig. 63.

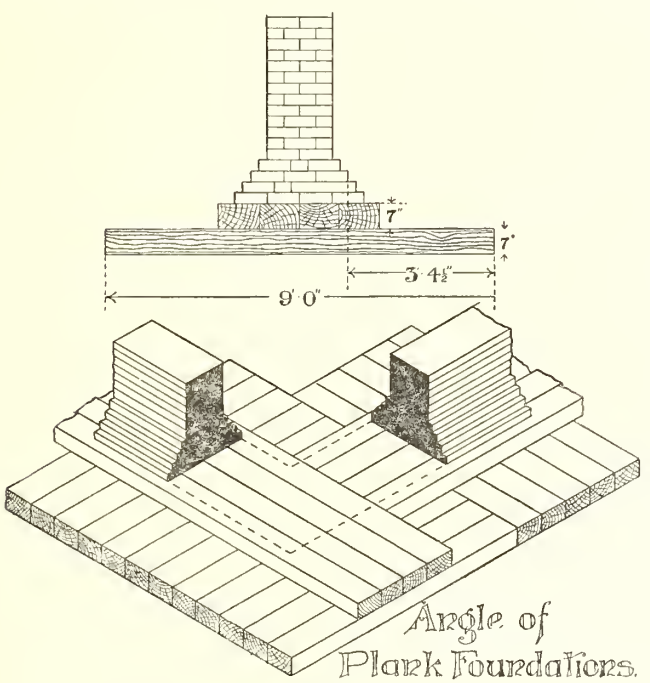


Fig. 64.

memel or more commonly elm, laid at right angles to the length of the wall, are used as a foundation. Such foundations are usually formed of two or more layers, the lower one being said to break joint to the full width required, and so to properly distribute the pressure, while the upper layer is laid in the direction of the wall and is made a little wider than the footings, the whole being securely spiked together as in Fig. 64.

Calculation of Plank Foundations.—Plank foundations are calculated in a similar manner to concrete foundations, as the following example will show: A wall 18 inches thick carries a load of 7 tons per foot run and rests upon an elm plank foundation, the safe bearing capacity of the soil being 0.8 tons per square foot. What must be the width and thickness of the plank foundation.

The total load upon the foundation-bed is 7 tons + 4 cwts. (the weight of the footings and planks).

Width of foundation

$$= \frac{\text{Total load in tons}}{\text{Safe resistance of soil in tons per sq. ft.}}$$

$$= \frac{7.2}{.8}$$

$$= 9 \text{ feet.}$$

The Thickness of the Planks is found from the formula—

$$d = \sqrt{\frac{6 \times W \times l}{2 \times C \times b}}$$

W in this formula represents the *ultimate* bearing capacity, so that the safe allowance must be multiplied by a reasonable factor of safety, say 5. Then

$$W = \frac{5 \times .8 \times 20 \times 81}{2 \times 12} \text{ cwts.}$$

$$l = \frac{81}{2} \text{ inches}$$

$$b = 12 \text{ inches}$$

$$C \text{ for elm} = 109 \text{ cwts.}$$

$$\therefore d = \sqrt{\frac{6 \times 5 \times .8 \times 20 \times 81 \times 81}{2 \times 12 \times 2 \times 109 \times 12}}$$

$$= \sqrt{\frac{10935}{218}}$$

$$= \sqrt{50.17}$$

$$= 7 \text{ inches approximately.}$$

It is a good plan to load plank foundations to the amount of the proposed superstructure, to prevent it from sinking when the latter is erected.

Pile Foundations.—Piles are long timbers, varying, for ordinary purposes, from about 10 to 40 feet in length, and shaped as shown in Fig. 13. They may be round or square in section, varying from 9 to 15 inches in diameter. Creosoted memel fir is generally used for piles on account of its suitability and cheapness, but oak, beech, elm, and pitchpine are often preferred.

The piles are usually pointed and shod with iron, as shown in Fig. 65, to prevent them from being split by stones or other hard substances with which they may come in contact when being driven.

The head if square should be neatly trimmed off to a circular shape, while if circular they should be trimmed off to a slightly smaller diameter, and a ring

of good malleable iron, varying from about ¾ to 1 inch in thickness and from 2 to 3 inches deep, is placed on the head of each pile.

Pile Driving.—Piles are driven by means of a heavy block of iron, called a ram or monkey, varying in weight from 200 to 3300 lbs., which is alternately raised and allowed to fall upon the head of the pile. The pile is supported against the upright member or guide of a pile-driving machine, while a rope is fastened to the monkey by means of a slip-hook and is pulled to a height of from 4 to 12 feet, when the slip-hook is released and the monkey falls upon the head of the pile. As the amount of penetration of the pile lessens under the blows of the ram the fall should be shortened, otherwise the fibres of the timber become strained.

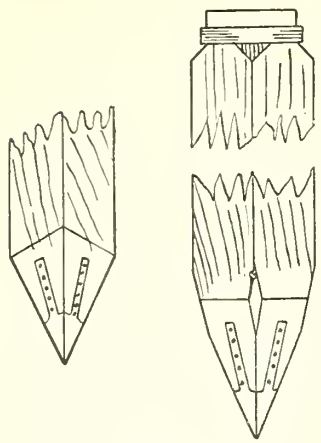


Fig. 65

Piles in foundations are used in five different ways—(*a*) as resistance piles, (*b*) as bearing piles, (*c*) as sheet piles, (*d*) as consolidating piles, (*e*) sand piles.

(*a*) Resistance or Friction Piles is the term applied to piles which are used to support a building by virtue of the resistance of their sides against the earth into which they are driven. They are used when a building is to be erected upon a layer of very soft earth of considerable depth, and vary in length from 15 to 40 feet according to the character of the soil.

The Bearing Power of Friction Piles is usually calculated by one of the numerous formulæ which have been devised for this purpose, of which the most popular—probably on account of its simplicity—is that invented by Major Sanders:—

$$\text{Safe load in cwts. upon each pile} = \frac{W h}{8 d}$$

Where W = weight of ram, in cwts.
,, h = height through which ram falls, in inches at last blow.
,, d = distance through which the pile is driven at the last blow, in inches.

This formula is satisfactory if the pile is driven an appreciable distance at the last blow of the ram, but if the amount of penetration is small it gives absurdly high values for the so-called safe resistance, until, when the pile refuses to sink under the blows of the ram, the bearing capacity as given by this formula is infinity, which of course is absurd.

A formula which seems to give a satisfactory result while it agrees with practically every building which has not settled to any appreciable extent is given by Trautwine—

$$\text{Safe load in tons} = \frac{\sqrt[3]{h \times W \times .023}}{d+1}$$

Where W, h, and d have the same values as in Major Sanders' formula.

A factor of safety of 2 is used when the piles are driven in firm soils, but this should be increased to 6 in muddy or marshy soils.

Of course, a trial pile must be driven to find the values in the above formulæ; but it is generally better to disregard formulæ and test the pile with a load.

When the piles have been driven to the required depths they are all sawn off level below the ground line, and horizontal timbers called sleepers, of the same size as the piles, are notched over and thoroughly spiked to them. Cross-pieces of the same section as the sleepers are then notched over and spiked to these, and the whole framework is filled in with concrete, as shown in Fig. 66. This method of notching is objectionable in very heavy buildings, as the fibres of the sleepers crush where they bear upon the piles.

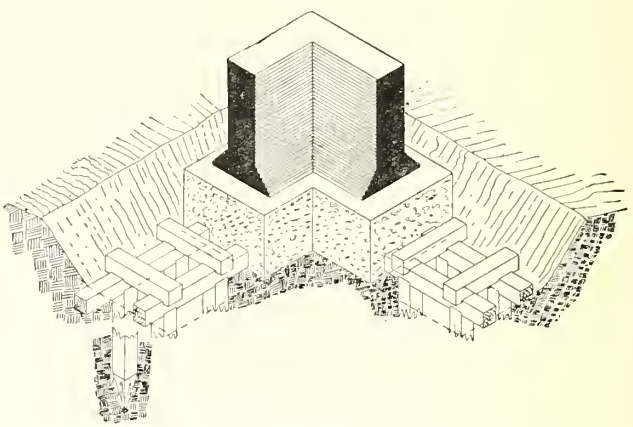


Fig. 66.

Sometimes, instead of cross-pieces, planks are laid close together across the sleepers, and on these the concrete bed is formed; while sleepers are often avoided altogether, the piles being left projecting a short distance from the bottom of the trench, and the concrete being filled in round them.

The custom of having the concrete in contact with wood is a bad one, as it causes the wood to decay, especially when the concrete surrounds it; and this fact has led to the practice of placing large slabs of stone upon the heads of the piles to form a base on which to raise the concrete. When such slabs are used care should be taken that all four corners of each, not only rest upon but bear thoroughly upon every point of the head of a pile.

(*b*) Bearing Piles.—When a soft soil, not greater than 40 feet deep, overlies a hard firm soil, piles are driven down through the soft into the hard soil, or in the case of a very hard substratum such as rock the

feet of the piles rest upon the rock, and perform to a certain extent the function of a column, save that lateral support is afforded by the soil, which of course varies with its nature. Such piles are called bearing piles.

The Bearing Power of Bearing Piles is sometimes calculated by means of Major Sanders' formula, but this should be avoided, as the formula was never intended to apply to bearing piles, the experiments upon which the formula is based having been carried out upon friction piles.

Professor Rankine's rule for the safe bearing capacity of piles is perhaps most frequently used, and is as follows :—

"In piles driven till they reach the firm ground, 1000 lbs. per square inch of area of head.

"In piles standing in soft ground by friction, 200 lbs. per square inch of head."

These rules apply to piles which are not driven more than $\frac{1}{5}$ inch by 30 blows of a ram weighing 800 lbs., and falling 5 feet at each blow.

The best plan is to drive a test pile and load it until sinking takes place, and to allow a certain factor of safety according to the nature of the soil.

Fig. 67 shows an angle of a building carried upon bearing piles. The piles are driven in rows at right angles to the walls, and a platform is built upon them as described in connection with friction piles.

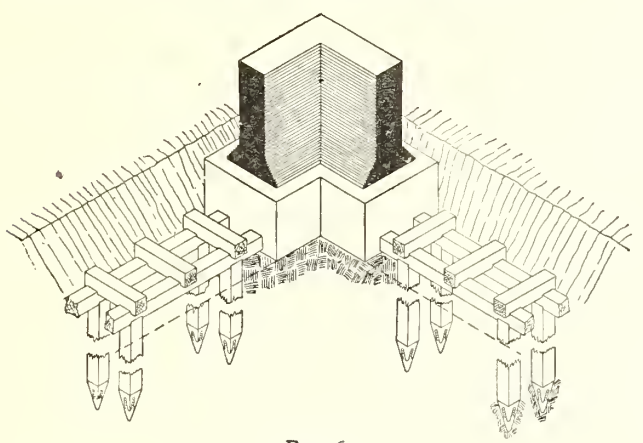


Fig. 67.

(*c*) Sheet Piles.—When a building is to be erected upon a soft soil, sand, loose gravel, or mud, the whole site is sheathed in piles to confine the soil, so that it may act as a homogeneous block, being unable to escape as it would certainly do were it not confined.

The method of sheet piling is as follows: The whole site is excavated to a depth of 2 feet or more. Piles, usually 9 inches square and upwards, and grooved on two sides, are driven in all round the site at intervals of from 6 to 10 feet. These piles, which are called *Guide Piles*, are left projecting about 2 feet from the bottom of the excavation, and two pairs of timbers, called *Wales* or *Waling Pieces*, usually 9 by 6 inches, are notched and bolted on to both sides of them, one pair at the bottom of the excavation and the other pair at the head of the pile as shown in Fig 68.

At the angles of a building a wale is notched and

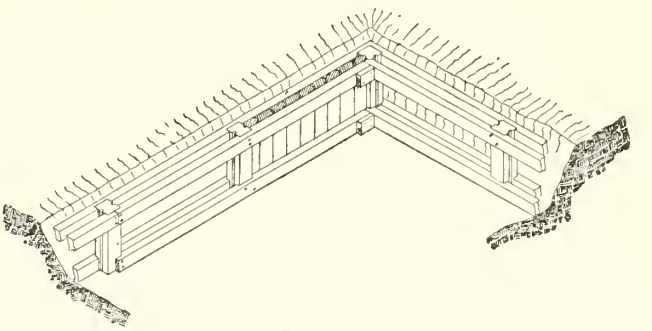


Fig. 68.

bolted to the corner guide pile and a cleat is bolted to one face to form a fixing for the other wale.

Sheet piles, from 8 to 11 inches wide and from $2\frac{1}{2}$ to 4 inches thick, are driven between these waling pieces, starting at a guide pile. These sheet piles are sharpened, as shown in Fig. 69, and shod with sheet

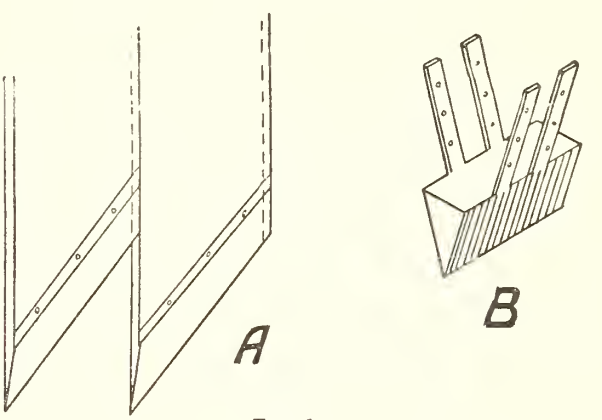


Fig. 69.

iron, as at A, Fig. 69, or with cast or malleable-iron blocks, as shown at B in the same Figure. The sloped foot of the sheet pile causes it to press against the pile last driven. The edges of sheet piles are bird's-mouthed or grooved and tongued so that they may form a closed joint when driven into position, as shown in Fig. 70.

Fig. 70.

When the piling is completed the site is covered with a bed of concrete, to prevent the soil from oozing up under the load.

(*d*) Consolidating Piles.—Some soils may be consolidated into homogeneous masses by driving in a number of piles all over a site. Such piles are called *Consolidating Piles*, and should not be driven closer than 2 feet 6 inches, centre to centre, otherwise they tend to loosen the soil rather than consolidate it. These

piles are often used in connection with sheet piling to consolidate the sheathed-up earth.

(*e*) Sand Piles.—In soft but dry earths, holes about 6 inches in diameter and 6 feet deep are often bored with an auger and filled with well-rammed sand. The columns of sand thus formed are used as friction piles. These are often preferable to timber piles, which transmit the pressure brought upon them in the direction of their length, while sand acts more or less as a liquid and transmits the pressure to the sides as well as to the bottom of the boring. When the jarring of driving wood piles would endanger adjacent buildings this system of piling is usefully employed.

Clustered Pile Foundations.—A method of forming foundation which sometimes proves very economical is that shown in Fig. 71. The piles, which may either be bearing or friction piles, are clustered together to form

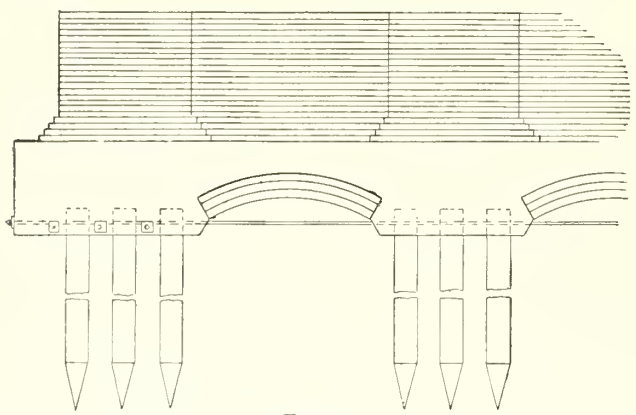


Fig. 71.

isolated supports. These are usually capped by large blocks of stone or concrete, forming skewbacks for arches which span the openings between the group of piles. Strong tie bolts are used to tie in the end abutment. Steels girders are sometimes used instead of arches, and it is often difficult to determine which is the more economical or sounder method to adopt.

Drawing Piles.—It sometimes happens that piles become damaged in driving, and have to be drawn. To do this, long arms of timber are bolted to the sides of the head, and are used as levers. Sometimes a temporary wooden structure is erected over the pile, from which hangs strong pulley tackle. The tackle is fixed to a strong screw eye fixed in the head of the pile, which is then drawn by tightening up the tackle with a winch.

A few smart taps on the side of the head of a pile will usually enable it to be drawn with comparative ease.

Pier Foundations.—When a hard substratum underlies a soft soil at no considerable depth, pits are excavated down to this substratum, and in these pits piers of brick, masonry, or concrete are built. The spaces between the piers are spanned by means of arches or steel girders, and upon this foundation the superstructure is raised.

Excavations for Piers.—If the soil is sufficiently firm the holes for the piers are excavated in the ordinary manner, the sides of the excavations being timbered as shown in Chapter II. These excavations are then fitted up with concrete, brickwork, or masonry, the timbering being extracted and the earth filled in where necessary as the work proceeds.

Brick Cylinders.—When the soil is of a soft nature, circular shafts are sunk as deep as possible without causing the earth to fall in, and a strong wood curb is placed round the bottom, as shown in Fig. 72. Upon

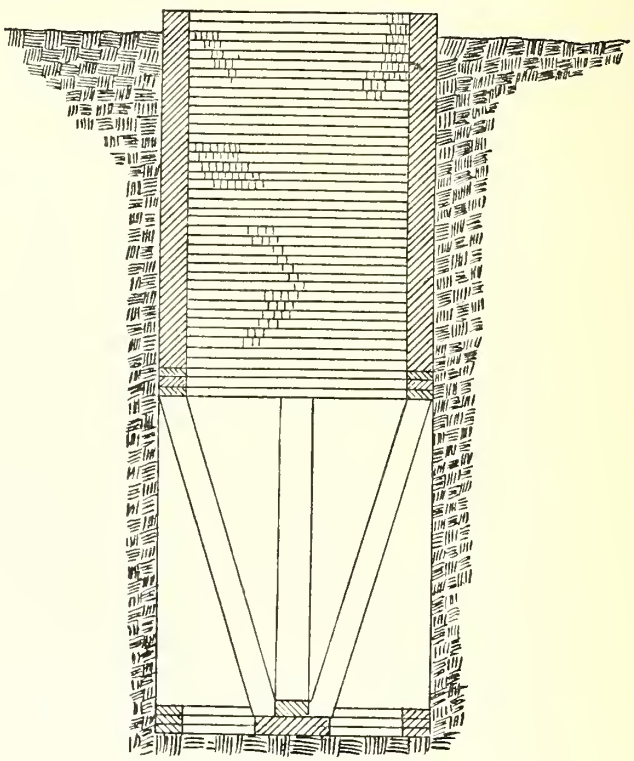


Fig. 72.

this curb a cylinder of brickwork is built up to the surface of the ground, care being taken to pack the earth well behind the brickwork as the work proceeds. A hole is now dug in the centre of the bottom of this brick cylinder, and a stout piece of timber, called a *Sole Piece*, is bedded at the bottom. Stout struts are then fixed to this, and placed so as to support the wood curb. The shaft is now excavated to the level of the sole piece, and a second curb is placed round the bottom, upon which more brickwork is built up until the first curb is reached. This operation is repeated until the desired depth is reached.

The following is another method of sinking brick shafts used in very soft soil: A strong curb with a sharp iron cutting edge is bedded on the surface of the ground, and brickwork is built upon it. The soil is excavated from beneath the curb, so that the whole

brick cylinder sinks by its own weight. As the sinking continues so fresh courses of brickwork are added until the cylinder has been sunk to the required depth. Great care should be taken to cause the cylinder to sink vertically, and if there is any tendency for it to do otherwise, the part which offers greatest resistance to sinking should be more heavily loaded than the rest.

Sometimes the friction of the earth on the outside of the cylinder prevents it from sinking altogether before the desired depth has been reached, in which case a smaller cylinder is sunk within the first cylinder.

Iron Cylinders or Caissons (see Fig. 73) are more convenient than brick cylinders, being composed of plates which are readily fixed together to form one mass, thus obviating all chance of splitting or of sinking obliquely. These are sunk in a similar manner to brick cylinders, fresh plates being bolted or riveted on as the sinking continues. When the cylinders of brick or iron have been sunk to the desired depth they are filled with concrete so as to form solid piers. These are spanned by means of arches or girders, upon which the superstructure is built.

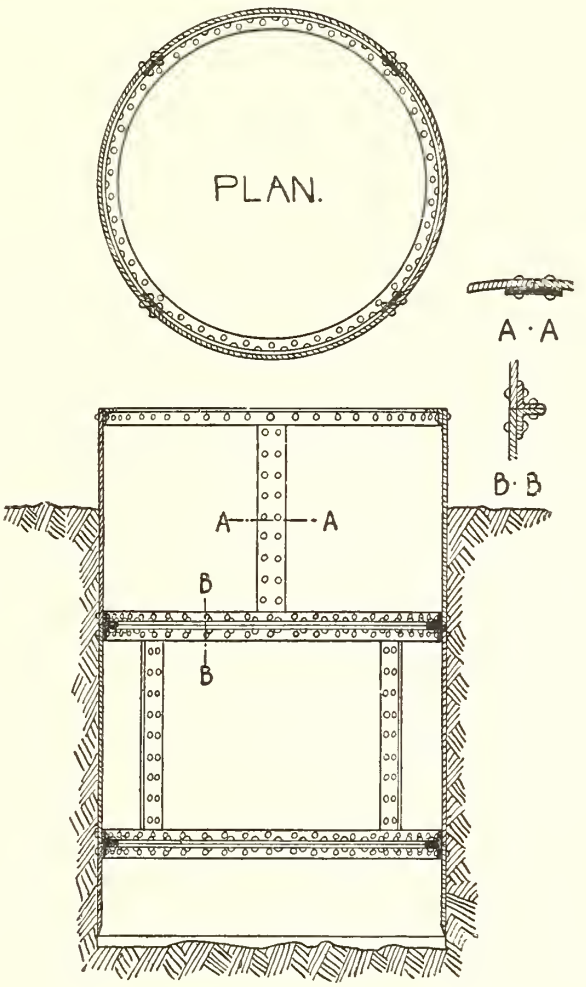


Fig. 73.

CHAPTER II

TIMBERING TO EXCAVATIONS

When earth has been excavated to a considerable depth the vertical faces of the excavations need supporting by means of timber, to prevent the soil from falling in and injuring the workmen or the work upon which they are engaged.

The strength of the timbering used for this purpose necessarily depends upon the nature of the soil, the depth of the excavations, and the length of time it is likely to be kept open.

Excavation in Firm Soil. — Fig. 74 shows the method of timbering a trench in firm ground, in which

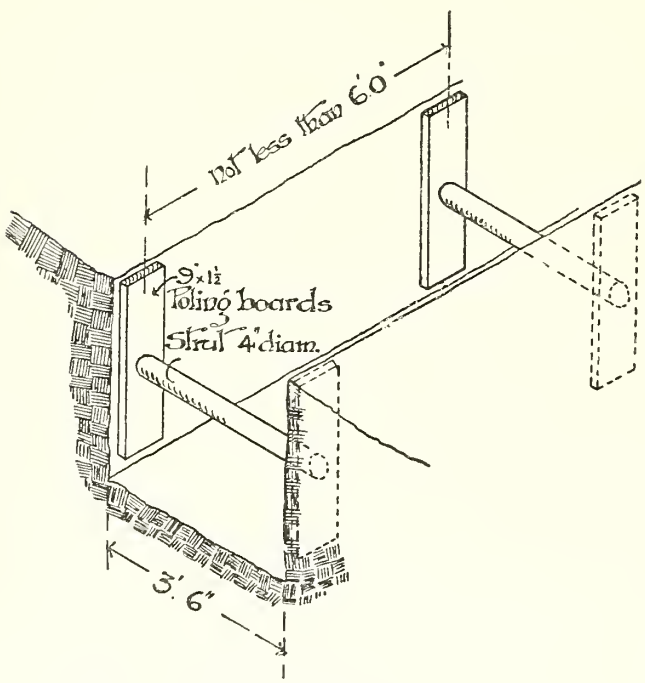


Fig. 74.

case short deal and batten "ends," varying from 1 by 4½ inches to 1½ by 9 inches, and about 3 feet long, called *Polings* or *Poling Boards*, are placed in pairs opposite one another against either side of the trench, and are held in position by means of struts. These struts, which are usually short lengths of 4 inches diameter scaffold poles, or 4 by 4-inch squared timbers, and cut about ¾ inch longer than the clear distance between a pair of poling boards, are fixed in position in the following manner: One end of the strut is placed against the middle of one poling board, and the other end is swung vertically downwards against the opposite poling board, and forced tightly against it by means of a few downward taps with a mallet.

The struts should not be closer together than 6 feet, otherwise they will prove a considerable inconvenience to the workmen in the trenches.

Excavations in Loose Soil.—Should the looseness of the soil necessitate supports being fixed at closer intervals than 6 feet the system of timbering shown in Fig. 75 should be used. In this case it will be noted

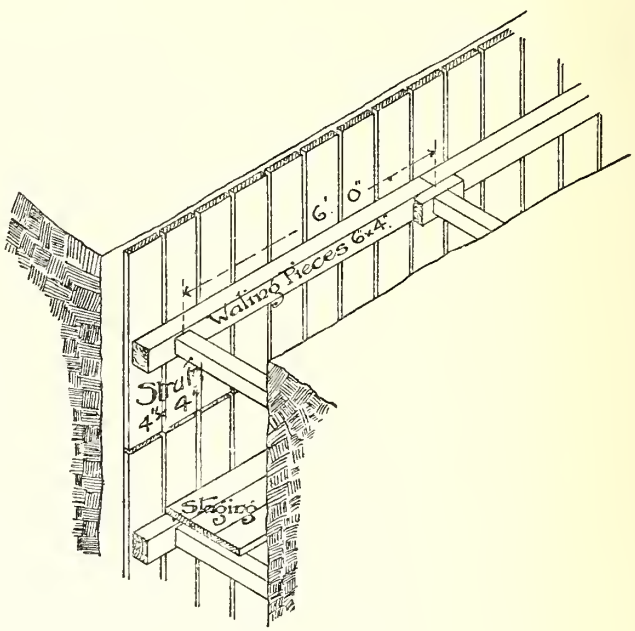


Fig. 75.

that the poling boards are supported by long horizontal members about 6 by 4 inches, called *Walings* or *Waling Pieces*, which in turn are supported by struts at intervals of 6 feet.

The method of inserting the timbering shown in Fig. 75 is as follows: A short length of trench is excavated, and a pair of poling boards are placed against its sides, and strutted with a temporary strut placed about 6 inches above the centre of the poling board. A little more of the trench is excavated, and the next pair of poling boards inserted. This process is continued until the trench is long enough to receive the waling pieces, which are held in position until the struts are inserted. The temporary struts are now knocked away, and one length of timbering is complete.

If the trenches are deep the timbering is inserted in

tiers until the required depth is reached, the struts being placed vertically under one another, and at a distance of about 6 feet apart, so that stages may be supported upon them for the disposition of the excavated soil—6 feet being the limit of depth from which an excavator can comfortably throw soil out of a trench.

When poling boards longer than 3 feet are used they should be supported by two rows of walings and struts, one row being placed near the top end of the poling pieces and one row at the bottom, the waling so that piece overlaps the end of the poling board by half its width. The upper ends of the poling boards of the next tier of timbering are inserted behind the lower waling pieces of the first tier.

Excavations in Bad Soil.—When the ground is so bad that it will not stand to a vertical surface while the

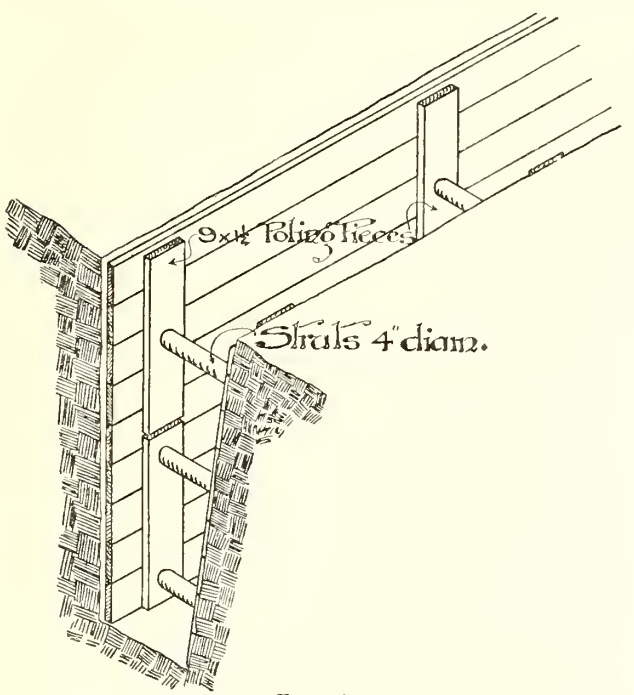


Fig. 76.

poling boards are inserted, the system of timbering shown in Fig. 76 is generally used, the method of inserting it being as follows: The trench is excavated to the desired width, and to a depth of about 9 inches. Two 9 by 1½-inch boards—which when used for this purpose are called *Sheetings*—are placed against the sides of the excavation and strutted apart with temporary struts. Another layer of soil or "spit" is excavated and another piece of sheeting inserted, with its edges placed as closely as possible to the edges of the first pair of sheetings. This process is continued until four or five boards have been inserted, when pairs of poling boards are placed vertically, and strutted against them, after which the temporary struts are knocked away. This whole operation may be repeated until the desired depth has been reached.

In shallow trenches the sides are battered or sloped to prevent the timbering from collapsing when the soil behind the sheeting sinks—as it frequently does owing to the water being withdrawn by gravitating to the bottom of the trench. Another advantage of a battered trench is that when narrow concrete foundations are to be placed therein it can be kept at the bottom to the calculated width of the concrete, the batter giving ample room for the men to work.

Excavations in very Soft or Water-Logged Soil require to be heavily timbered to resist the considerable lateral pressure of the soil. The usual method

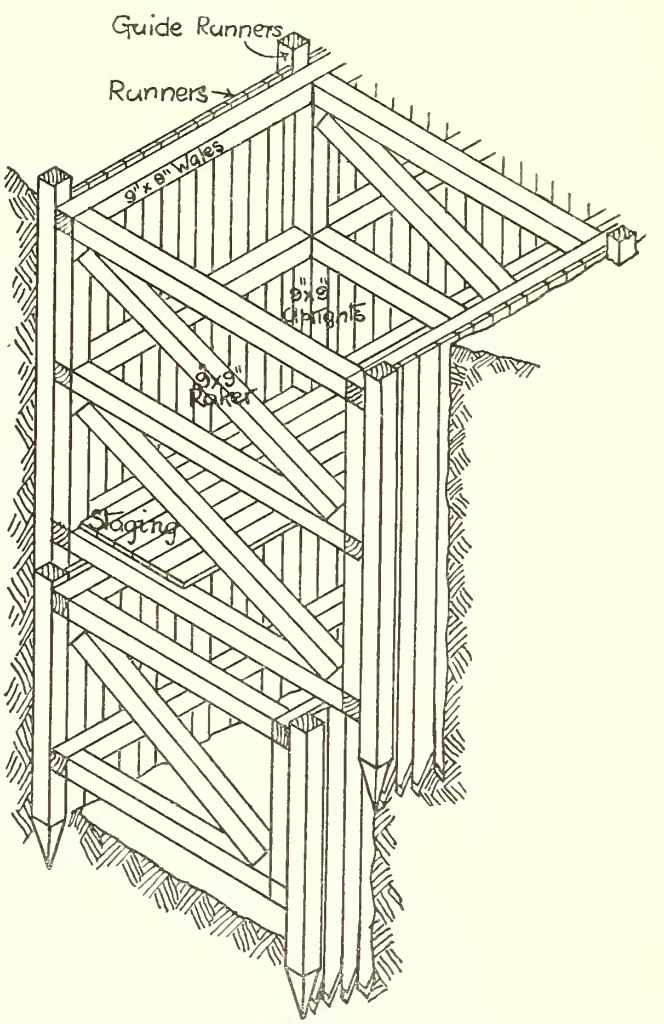


Fig. 77.

of timbering excavations in such soils is as follows: Guide piles or *Guide Runners*, 9 by 9 inches,—as they are called when used for timbering excavations,—are driven into the ground at intervals of about 10 feet on either side of the piece of ground it is desired to excavate. Stout waling pieces are bolted to these guide runners, and sheet piles, 9 by 2 inches to 11

by 3 inches, and about 10 feet long, called *Runners*, are driven a short distance into the ground behind the waling pieces to form a continuous wall between the guide runners. The soil is now excavated between the two rows of runners, care being taken not to excavate within a foot of the bottom of the runners. The runners are now driven a farther distance and another layer of soil is excavated, this process being continued until the heads of the runners are driven flush with the ground, struts being placed at frequent intervals to prevent them bulging inwards. If an excavation deeper than one set of piles be required, another set of piles is driven within the first, and if the excavation be very wide, vertical pieces are inserted between the wales; and to prevent the horizontal struts from bending under the pressure from the earth, inclined struts, called *Rakers*, are inserted between them, as shown in Fig. 77. These rakers are fixed at one end to cleats immediately under a horizontal strut, while the other end is fixed to a cleat on top of the next lower horizontal strut on the opposite side of the excavation. It will be noticed that the runners are pointed in a similar manner to the piles described in Chapter I., save that here a greater splay is given to the edges facing towards the excavation, in order to cause the runner to press against the retained earth on being driven.

Excavations to Pier Shafts.—When excavating for a shaft a hole is excavated as deep as possible without the earth falling in. Vertical sheeting from 9 by 1 inch to 9 by 2½ inches, according to the nature of the soil, is temporally strutted against the faces of the excavation

Walings running right across the excavation are held in position against two opposite sides and strutted by means of walings forced between them against the other two sides. Cleats are fixed to the ends of the first pair of walings, so as to prevent the other pair of walings from being forced out of position.

Another layer of earth is now excavated and a second tier of sheeting is placed with the upper end overlapping the lower end of the first tier, and a second row of walings is inserted to secure both tiers together, and uprights are placed tightly between the walings at the corners of the shaft.

When the shaft is of considerable depth the timbering is prevented from sliding down the shaft by making one pair of walings to project well beyond the shaft at the top and to rest upon the surface of the ground, as in Fig. 78, a timber being notched over all the walings to act as a tie. If the shaft be very deep a pair of the bottom walings is buried in the side of the cutting, being formed in two pieces with a keyed and scarfed joint in the middle similar to A (Fig. 251 and Plate VI.).

Excavations to shafts should never be less than 4 feet square, as a man cannot work in a less space than this.

The above system of timbering may be used for shafts up to about 10 feet square; but if shafts larger than this have to be sunk, the system shown in Fig. 79 must be used. In this case the sheeting and waling

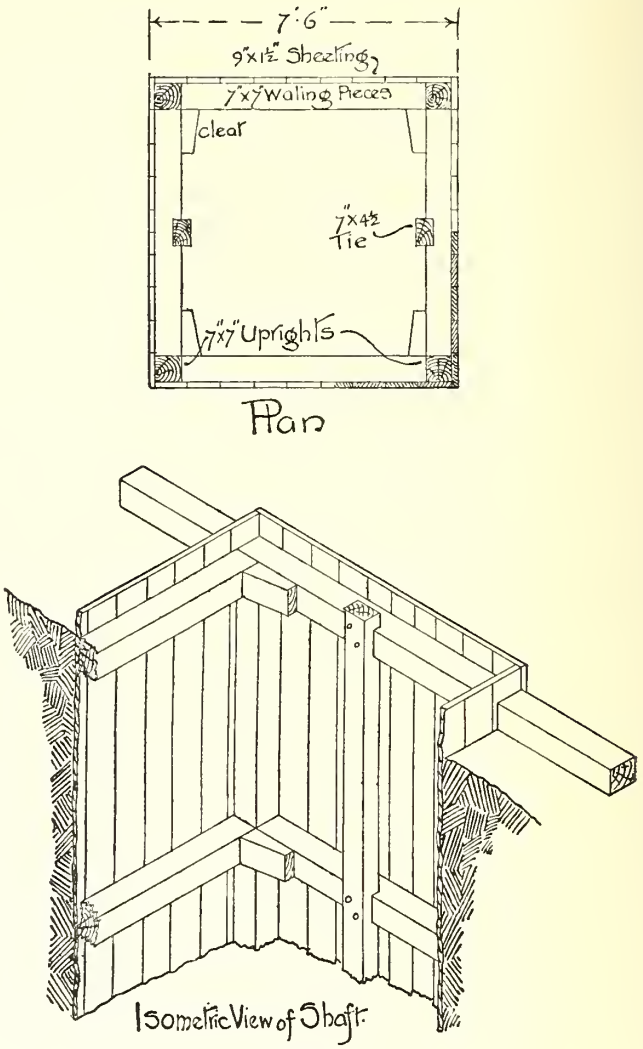
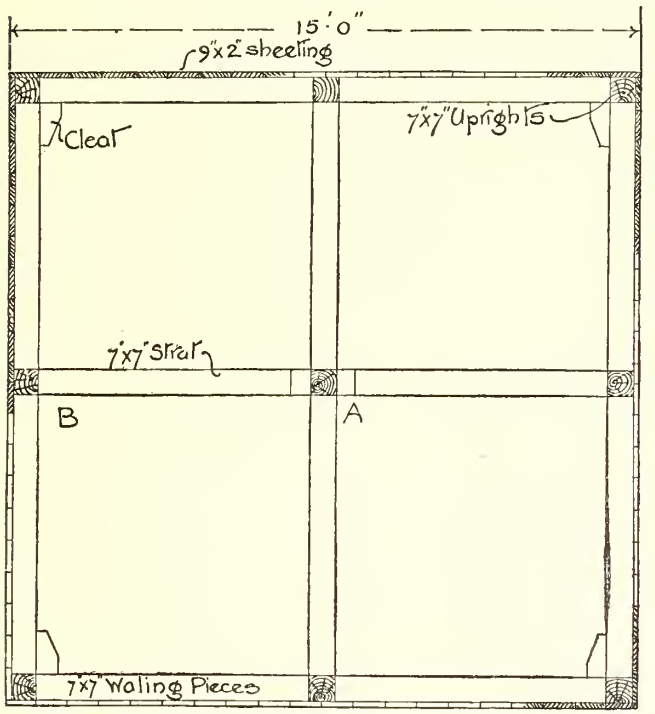


Fig. 78.

pieces are inserted as explained with reference to Fig. 78, and two struts are placed at right angles to one another across the centre of the shaft, one of these struts being in one piece and the other in two pieces, the ends of the latter being supported at one end by small pieces of timber placed between the side walings and the uprights, and at the other end by similar small pieces of timber placed between the central struts and uprights, as shown by the disjointed details in Fig. 79.

Excavating Tunnels.—It is sometimes far more economical to cut tunnels for such work as drain laying than to excavate very deep trenches. These tunnels may be of any size; but they are usually just

large enough to enable one man to work, *i.e.* not less than 4 feet square. The method of excavating a tunnel is as follows: If the soil is good, sections from 2 to 3 feet long are dug out, poling boards are then temporarily fixed round the opening, a head-piece held in position, and finally strutted by means of upright struts, as shown in Fig. 80, these latter being kept in position by



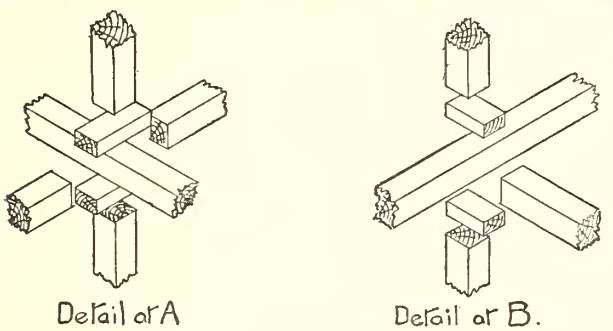


Fig. 79.

spiking them to the head or by having cleats fixed to the head. Another length of tunnel is excavated and another series of poling pieces is inserted with the ends overlapping the first series of poling pieces, and another frame composed of head and struts is fixed against these overlapping ends.

Failure of Timbering.—Serious accidents happen from time to time owing to the failure of timbering

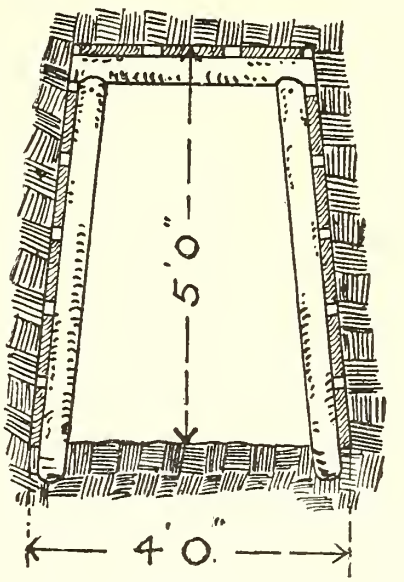


Fig. 80.

in excavations. This failure is usually due to one of the following two reasons:—

1. The struts fail under the pressure of the earth; or,

2. The struts drop out by the shrinkage of the soil.

1. This is perhaps the most frequent cause of failure, as the pressure from soils is often underestimated, particularly that of clay soils, which sometimes swell with enormous force when exposed to the atmosphere. When excavations are made in soft soil in the vicinity of heavy buildings the lateral pressure of the soil is usually very great.

To prevent such failures the timber should be of ample size, and should be examined before being inserted in the excavations, and all faulty pieces rejected; while in very deep trenches the struts in the lower parts of the trenches should be larger than those near the surface.

2. To prevent struts dropping out of place they should be examined from time to time and tightened when necessary; but a better plan is to spike them to the walings or to fix cleats underneath them. The struts supporting stages should always be spiked or fixed in some way, as they are very likely to become loosened by the weight and motion of the excavator, who stands upon them to work.

CHAPTER III

BOND IN BRICKWORK: ENGLISH BOND

THE manner in which bricks are arranged in a wall is obviously of great importance to the appearance and strength thereof. Thus in Fig. 81, which represents an angle of a 14-inch brick wall, it is clear that if the foundations upon which it is built were to settle irregularly the wall would split from top to bottom along one or more of the continuous vertical joints *ab*, *cd*, etc., according to the nature of the settlement. In fact, the wall would act simply as a number of separate piers, with nothing to bind them together save the adhesion of the

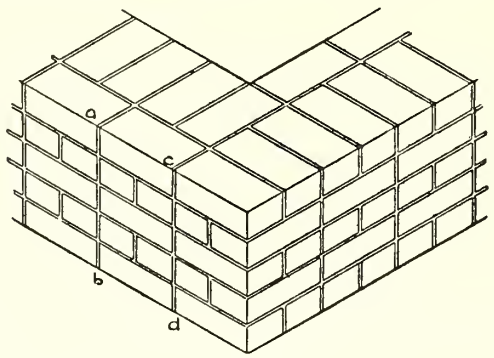


FIG. 81.

mortar. Now if a closer, or half-brick cut longitudinally, be inserted next to the smaller end of the corner brick and continued through the thickness of the wall in every course, as in Fig. 82, it will be seen that each brick overlaps the bricks with which it is in contact, thus entirely avoiding the continuous vertical joints referred to above. In building a brick structure, therefore, care should be taken to lay each brick so that it will overlap the bricks with which it is in contact above and below, in such a manner that the whole wall will act as a homogeneous mass. This process of overlapping is called "*Bonding.*"

VARIOUS SYSTEMS OF BONDING.—The following are the principal forms of bonding: English, English Cross, Double Flemish, Single Flemish, Heading, Stretching, Raking, Garden Wall, Boundary Wall, Sussex, Scotch, and Dutch.

The following rules relate to good bonding in all walls of any bond whatever:—

RULES FOR GOOD BRICK BONDING.—

1. The bricks must be uniform in size.

2. The arrangement of the bricks should be uniform throughout the wall.

3. Bats, *i.e.* small portions of bricks, should be used as little as possible.

4. The bricks in the interiors of walls should be laid as headers, that is, across the wall, except in some special cases, such as footings, corbels, and cornices.

5. The lap should not be more than $2\frac{1}{4}$ inches.

6. The vertical joints in every other course should be vertically over one another, whether on the face or in the interior of a wall, or, as expressed in technical language, the *prepends should be kept.*

ENGLISH BOND.—The appearance of a wall in English bond is shown in Fig. 82. The facing bricks are laid in alternate courses of headers and stretchers, with queen-closers inserted next to the quoin-headers to cause the bricks to overlap properly. It will be found instructive to notice in Fig. 82 that it does not matter whether the line AB represents a stopped end, an external angle formed by the junction of two walls, or

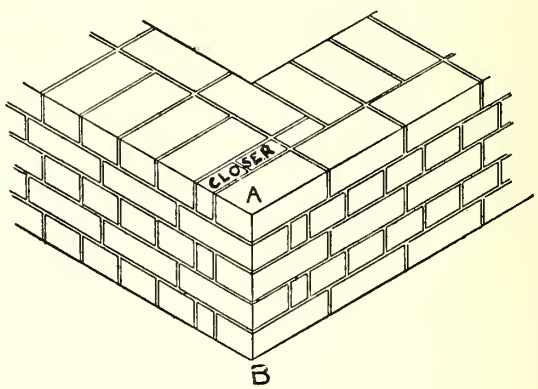


FIG. 82.

plain or rebated jambs to openings, the appearance of face is precisely the same in all cases.

English bond is undoubtedly the strongest, as it almost entirely avoids continuous vertical joints (see Fig. 83, where the blackened joints are continuous), and this fact alone should commend it to general use; yet many object to its use on the ground that the numerous transverse joints permit the penetration of damp, and that its appearance is not as good as that of brickwork bonded in Flemish bond. These are false objections, however, as there is no more likelihood of damp penetrating a wall in English bond than any other bond, provided the bricks are thoroughly flushed up with mortar.

Also if the appearance were objectionable, there is no reason whatever why strength should be sacrificed for so minor a consideration.

RULES FOR ENGLISH BOND.—It is not unusual to find a novice poring hopelessly over a set of plans of alternate courses of bricks in walls of various

thicknesses, in the vain endeavour to remember each one as something separate and apart from every other. This is what he should most carefully avoid, and instead he should learn the few simple facts common to all walls bonded in any particular manner. The following rules should be observed in building walls in English bond.

1. There should always be a quoin-header (or, in other words, a header should come at the corner or quoin) in every other course.

2. There should always be a queen-closer next to the quoin-header, and this closer should be continued through the thickness of the wall.

3. In walls of an even number of half-bricks in thickness (*i.e.* 9, 18, 27-inch, etc., walls) that course which shows headers on the face will also show headers on the back, while that course which shows stretchers on the face will show stretchers on the back.

4. In walls of an odd number of half-bricks in thickness (*i.e.* 14, 22½-inch, etc., walls) that course which shows headers on the face will show stretchers on the back, while that course which shows stretchers on the face will show headers on the back.

These rules are exemplified in Fig. 83, in which are shown two courses of each of the most generally used thicknesses of walling in English bond, with a stopped end and corner in each case.

Diagram for Bonding Walls in English Bond.—The above rules can be more readily remembered in a diagrammatic form. Thus Fig. 84 shows all the rules at a glance, and it can be committed to memory in a few minutes. This diagram enables anyone to bond plain walls, right-angle junctions of walls, whether of equal or unequal thickness, and stopped ends to walls. The application of the diagram is best illustrated by means of an example. Suppose we have a wall 27 inches thick meeting a wall 18 inches thick at right angles, the external faces of the walls being 3 ft. 11 in. and 4 ft. 6 in. in length respectively, the ends A and B being stopped at right angles with face of the wall. Draw the block plan as in Fig. 85. Draw on the facings, the external facings being those shown at A on the bonding diagram in Fig. 84, and the internal facings in this case being those shown at B, and carry the queen-closers through the entire thickness of the wall (see shaded portion, Fig. 85).

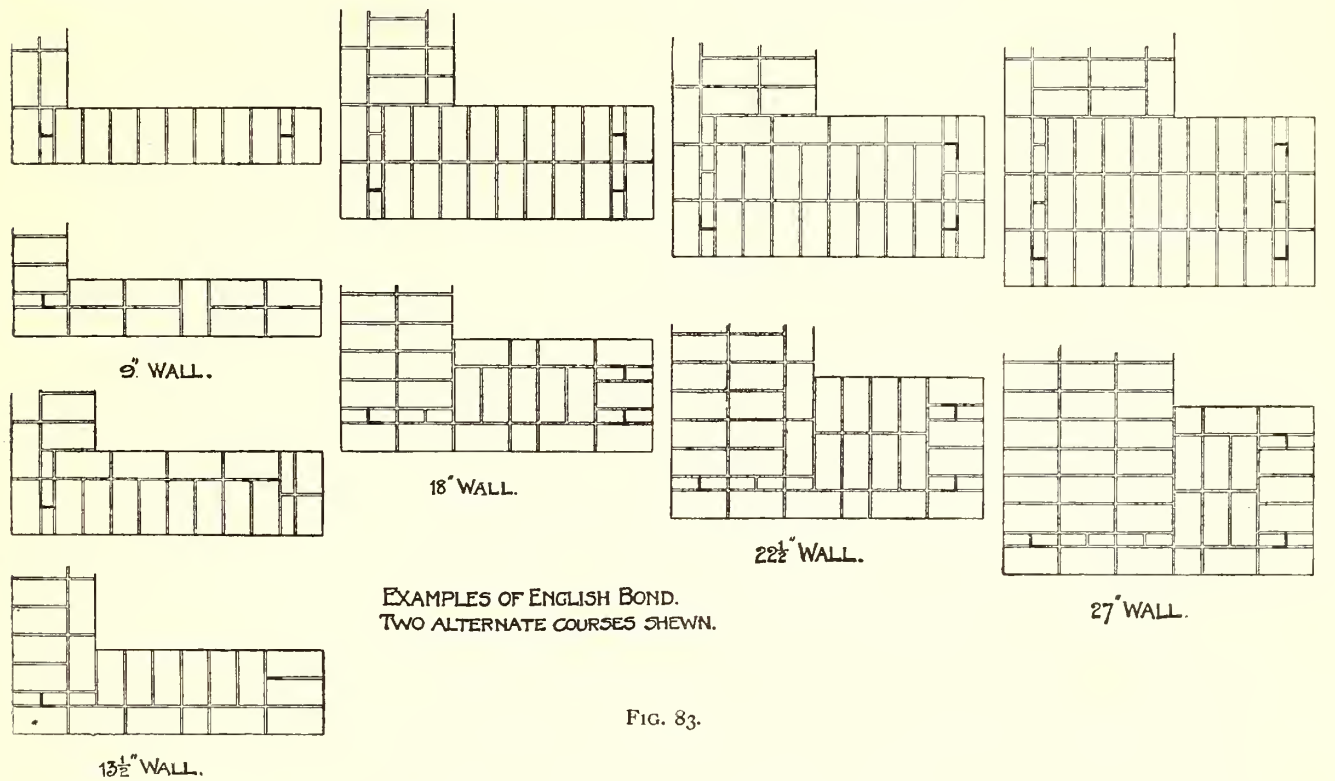


Fig. 83.

Now fill in the intervening spaces with headers, and one course of the brickwork will be complete. The next course of bricks is formed in exactly the same manner, by taking the bonding diagram and turning it over on the axis OP, and viewing it through the back of the paper on which it is printed. It would be well for the novice to draw a number of plans of alternate courses of brickwork by means of his diagram, and in a very short time he will find that he is able to draw such plans of brick wall in English bond without its aid. Fig. 83 shows alternate courses of bricks in right-angle junctions of walls of various thicknesses, to which the reader may compare his own plans obtained by the application of the diagram. It should be noticed that, where walls of equal thickness meet at right angles, it is only necessary to make the plan of one course; for in order to obtain

the course above and below it is only necessary to make a tracing of any course and turn it over and view it through the back of the tracing paper, and if it is desired to test the bonding the traced course should be laid over the plan of the course from which it was traced.

joints, and these considerably weaken the angle, whereas in the method shown in Fig. 83 vertical joints are almost entirely avoided at the angles. Small continuous vertical joints also occur in English bond at the stopped ends of walls, the continuous vertical joint

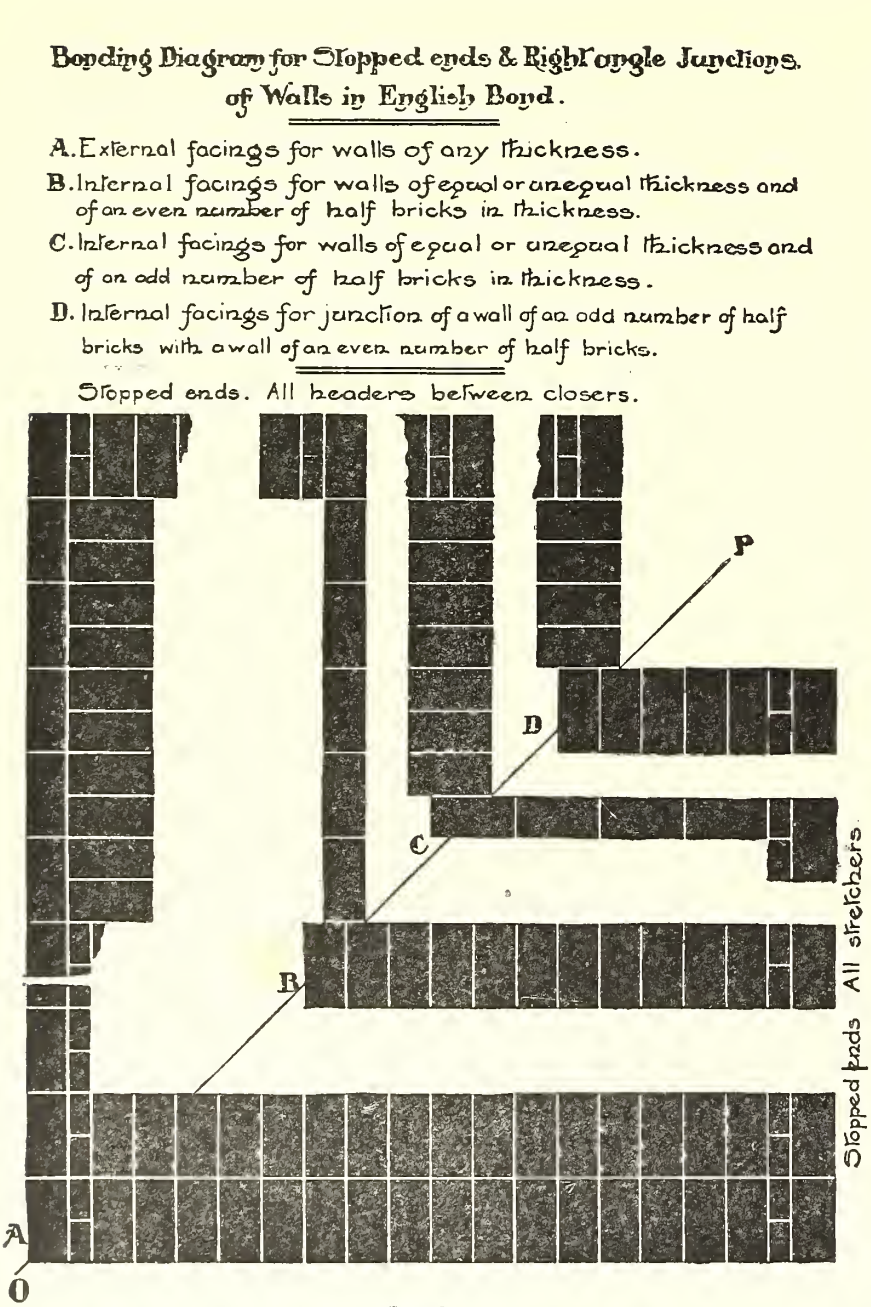

Bonding Diagram for Stopped ends & Right angle Junctions of Walls in English Bond.
A. External facings for walls of any thickness.
B. Internal facings for walls of equal or unequal thickness and of an even number of half bricks in thickness.
C. Internal facings for walls of equal or unequal thickness and of an odd number of half bricks in thickness.
D. Internal facings for junction of a wall of an odd number of half bricks with a wall of an even number of half bricks.
Stopped ends. All headers between closers.
P
D
C
B
A
O
Stopped ends. All stretchers.

Fig. 84.

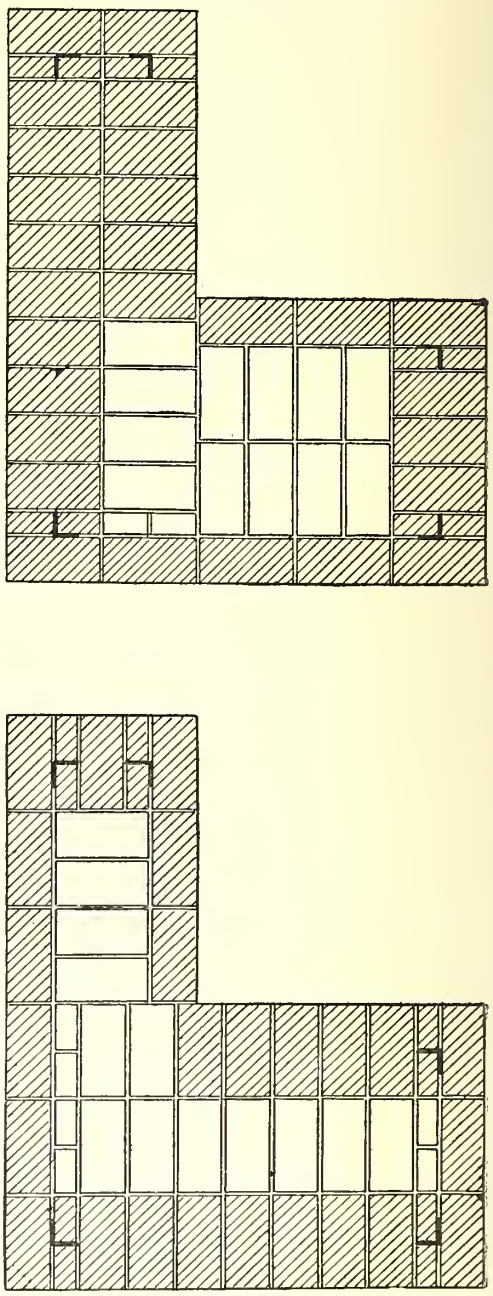


Fig. 85.

Of course it is possible to bond walls in a different manner to that shown in Fig. 83, and yet keep the facings the same. The usual difference met with in practice is the position of the queen-closers, a very common arrangement being that shown in Fig. 86. The objection to this arrangement is that continuous vertical joints are produced as shown by the blackened coinciding with the joints in the closer. Both these defects are small enough to be inconsiderable.

Plain Jambs.—The vertical sides of openings in walls are called jambs, and they are formed in precisely the same manner as stopped ends, as shown in Fig. 83.

Rebated (or Rabbeted) Jambs.—Jambs formed in

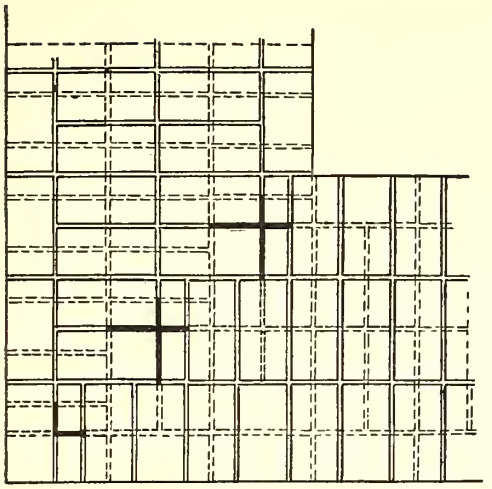


FIG. 86.

two planes, one recessed behind the other, as in Fig. 87, are termed rebated jambs. The recessed jamb is sometimes called the internal jamb, while the projecting jamb is called the external jamb, or *Reveal*.

The method of bonding the bricks in rebated jambs in walls in English bond is shown in Fig. 87. The internal jambs are usually recessed by a distance equal to some multiple of a quarter of the length of a brick.

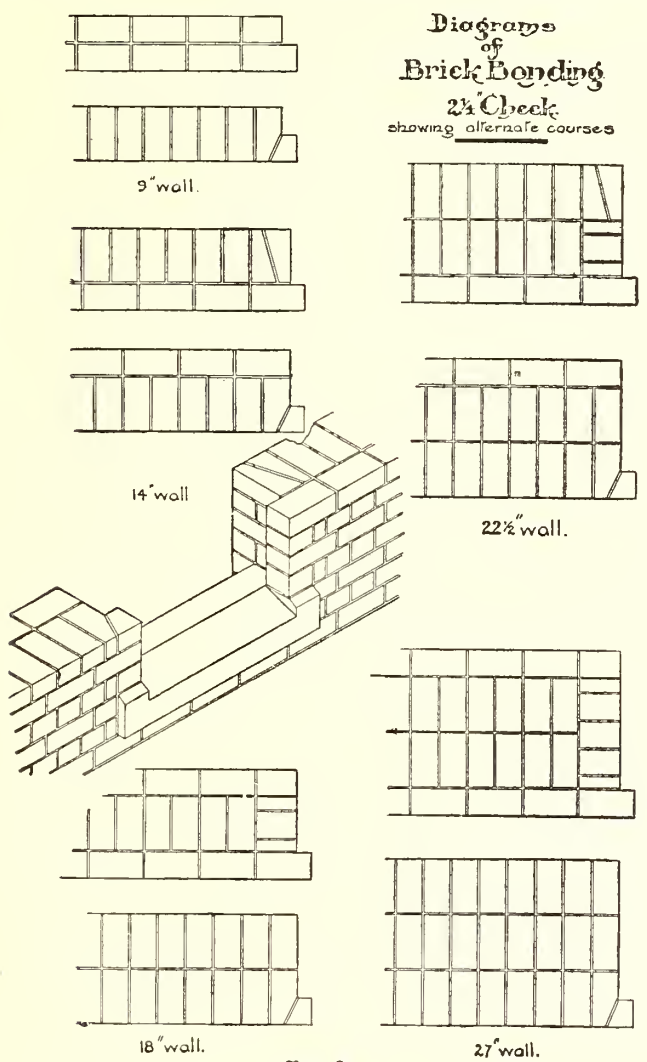


FIG. 87.

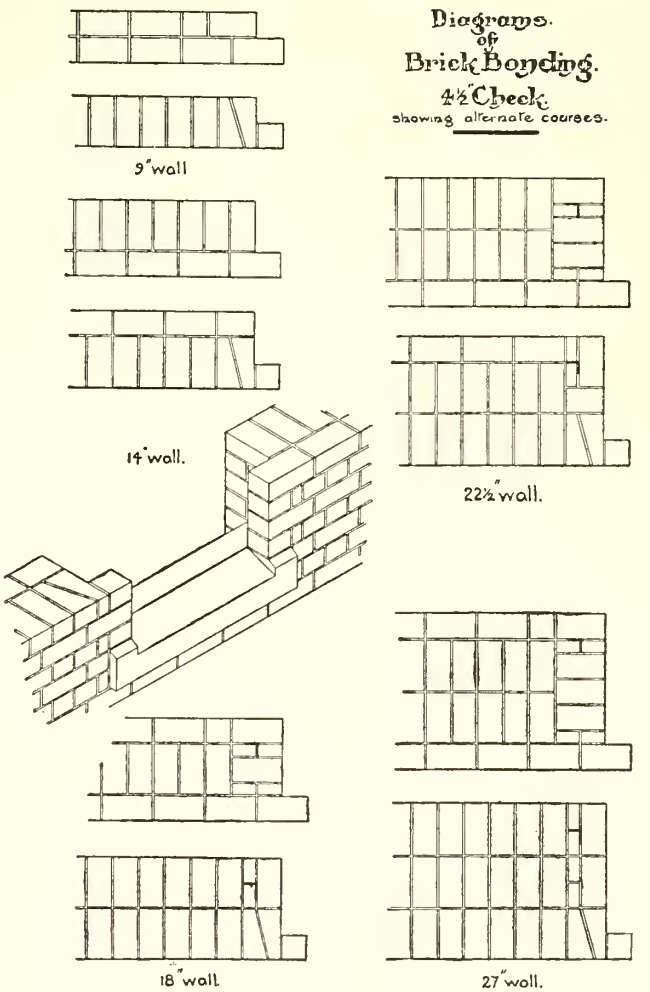


FIG. 88.

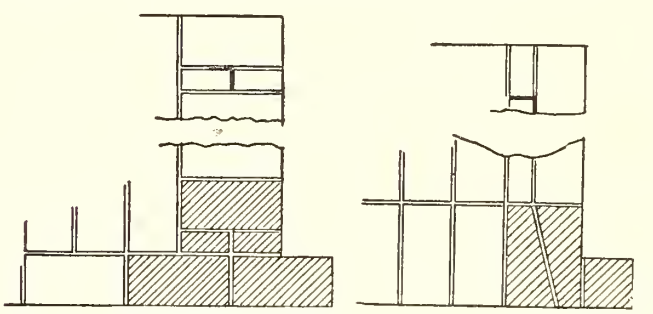


FIG. 89.

Fig. 87 shows alternate courses of bricks for a rebated jamb, with the reveal projecting $2\frac{1}{4}$ inches from the internal jambs.

Reveals of $4\frac{1}{2}$ inches projection and $4\frac{1}{2}$ inches in width are perhaps more often used than any others, and the method of forming them is shown in Fig. 88. The method is the same in every case, save for slight modifications. In one course the projecting reveal is formed by means of a half-brick. Next this half-brick is a king-closer, splayed from $4\frac{1}{2}$ inches in width at one end to $2\frac{1}{4}$ inches at the other end, the smaller end being laid flush with the face of the wall. Another similar king-closer is now laid beside the former one, with its larger end flush with the face of the wall, and the course is continued with headers on the face of the wall to the required length. This completes one course of a 9-inch wall. If the wall is more than 9 inches thick the internal jamb is completed by laying stretchers along the face of the internal jamb to the required thickness. A queen-closer is placed next to the *scontion* or internal corner brick, and continued to meet the king-closer. The wall is then continued in the usual manner of walls in English bond.

There are slight modifications to this system of bonding reveals which occur in the case of walls of an odd number of half-bricks in thickness when it is impossible to make all the bricks forming the internal jamb stretchers. Bats must be used in such cases, and it need scarcely be remarked that to use a three-quarter-bat instead of a half-bat and a $4\frac{1}{2}$-inch queen-closer makes a stronger job. These bats are always laid along the ends of the king-closers (see the $22\frac{1}{2}$-inch wall in Fig. 88).

The next course is formed by laying a stretcher along the face of the wall with one end flush with the reveal of the half-brick in the course below, when the internal jamb is finished precisely in the same manner as a stopped end, and the wall is continued as a wall in English bond (see Fig. 88). This method of bonding $4\frac{1}{2}$-inch reveals may be seen at a glance from Fig. 89, in which the shaded portions represent the arrangement common to every case, while the bricks left white indicate the manner of building walls over 9 inches thick, save for the obvious modifications mentioned above.

Reveals of $4\frac{1}{2}$ inches projection and 9 inches in width are sometimes used in walls of one and a half bricks or more in thickness. The method of forming these is as follows: In one course the reveal is formed by laying a brick as a header to the face of the wall, next to this is placed a 9-inch queen-closer; while the internal jamb is formed by laying a king-closer with its smaller end abutting against the internal end of the queen-closer; and if the wall is more than two bricks in thickness the internal jamb is finished with stretchers laid along its face if the walls be an even number of half-bricks in thickness (Fig. 90), and with stretchers and bats if the wall be an odd number of half-bricks in thickness.

A header is laid next to the external queen-closer, and a king-closer is placed next the former king-closer. A queen-closer is placed next the scontion brick, and

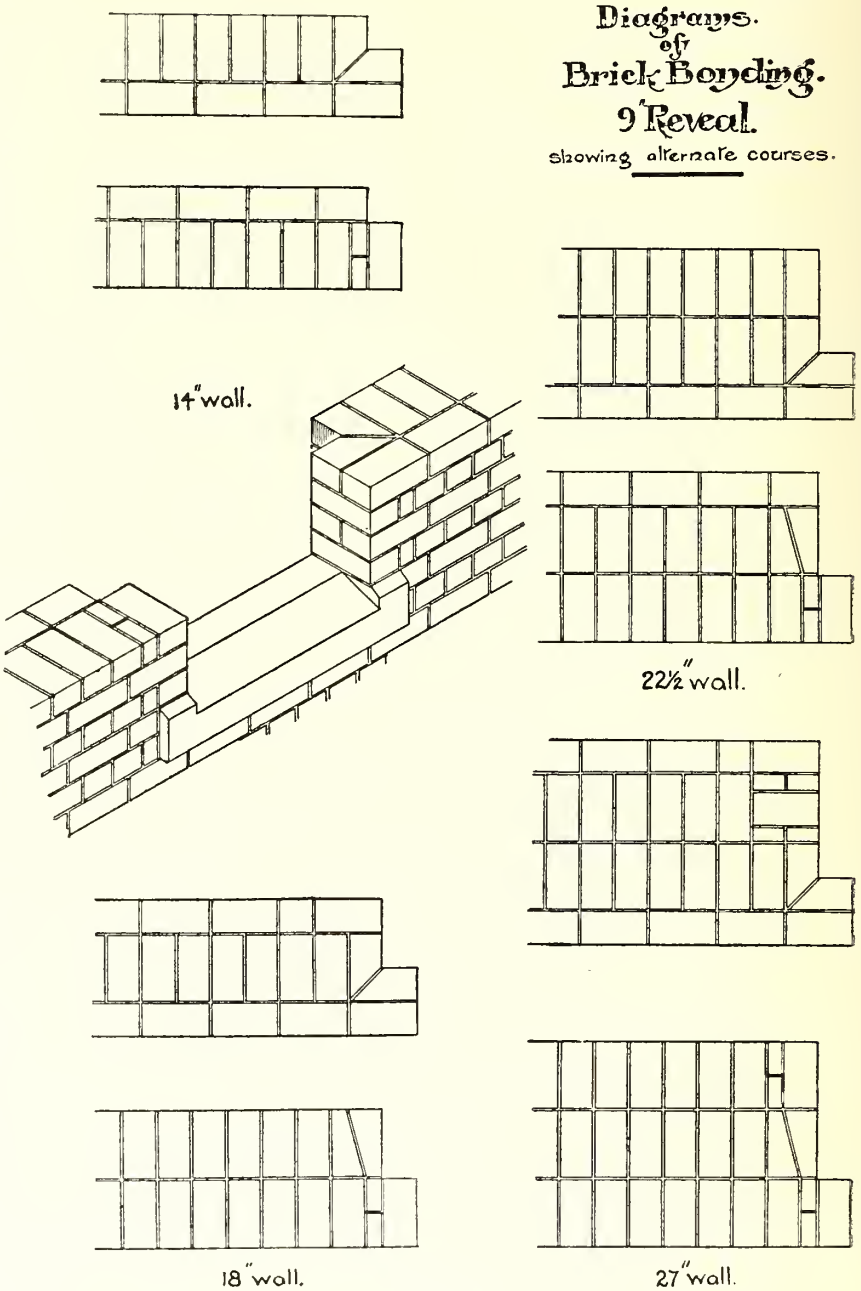


Fig. 90.

the wall is then continued after the manner of walls in English bond. In the next course the reveal is formed by laying two bricks as stretchers to the face of the wall, the internal one being bevelled from one corner at 45 degrees, and mitred with a similar brick, which later forms part of the internal jamb. The remainder of the jamb is formed as a stopped end, the wall is continued

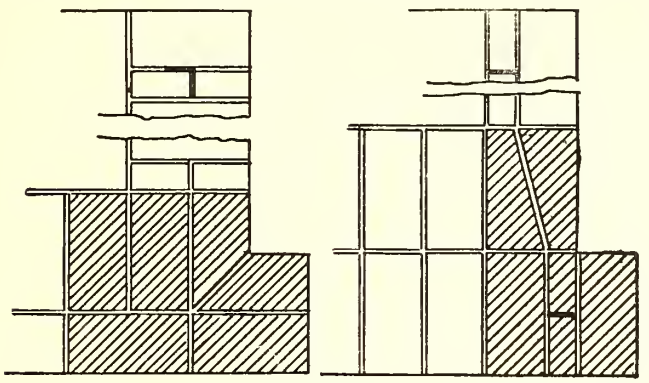


FIG. 91.

as a wall in English bond. The facts common to rebated jambs with 9-inch reveals are clearly shown by the shaded bricks in Fig. 91, while the bricks left white show how the walls are built when they exceed two bricks in thickness.

The simple modifications in the case of walls of an odd number of half-bricks in thickness should be noted.

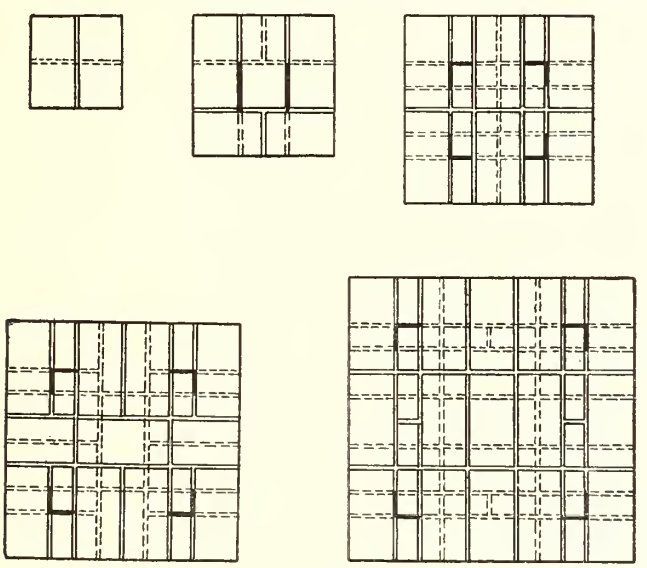
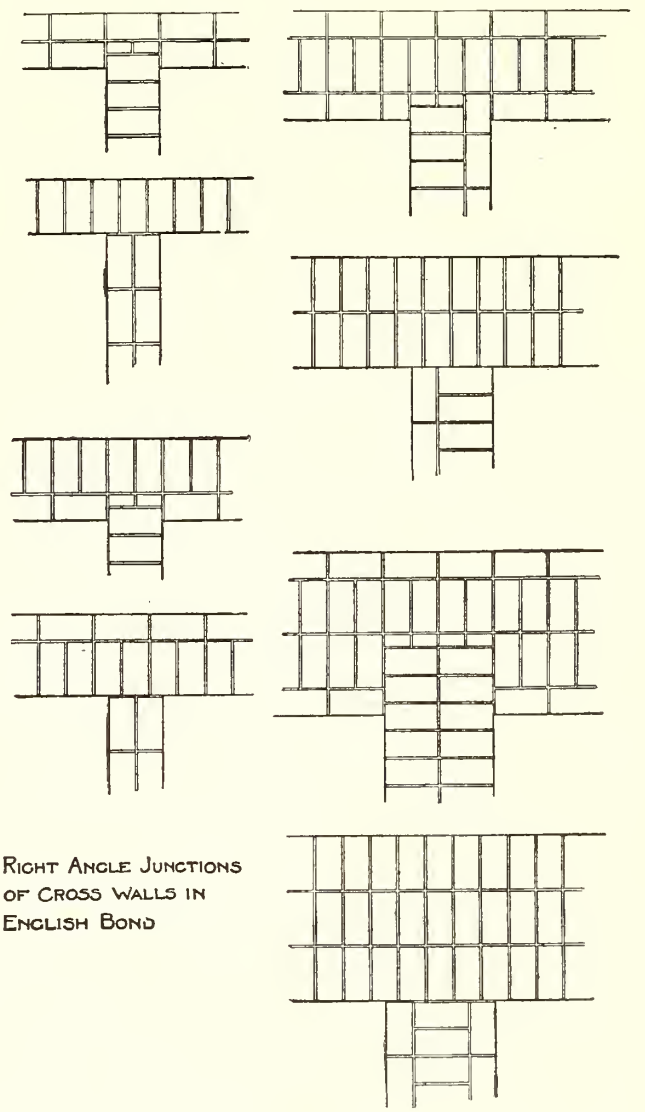


FIG. 92.

RECTANGULAR PIERS.—These are practically formed like stopped ends placed end to end, as in Fig. 92.

RIGHT-ANGLE JUNCTIONS OF CROSS WALLS.—When a cross wall meets a main wall at right angles the bond is produced as shown in Fig. 93. One course of the cross wall overlaps the main wall by $4\frac{1}{2}$ inches, a sufficient number of headers of the main wall being omitted to receive it. A queen-closer is inserted $2\frac{1}{4}$ inches from the face of the main wall to give the necessary lap in the cross wall, and the wall is continued from this closer in the ordinary manner. The next course of the cross wall is simply butted against the face of main wall.

In the case of thick walls it is considered by many that a stronger junction is made if the one course of the cross wall projects within the main wall more



RIGHT ANGLE JUNCTIONS OF CROSS WALLS IN ENGLISH BOND

FIG. 93.

than $4\frac{1}{2}$ inches, as shown in the lowest drawing in Fig. 93.

CROSS WALLS AT VARIOUS ANGLES.—When the cross walls meet the main walls obliquely it only requires a slight modification of the above method to secure good bonding. The headers where one course of the cross wall penetrates the main wall must be as large as possible, and pieces of brick cut to various shapes as the case requires must be inserted in place of

the queen-closers in right-angle junctions, which pieces must be as large as possible, and at the same time not large enough to lessen the amount by which the cross

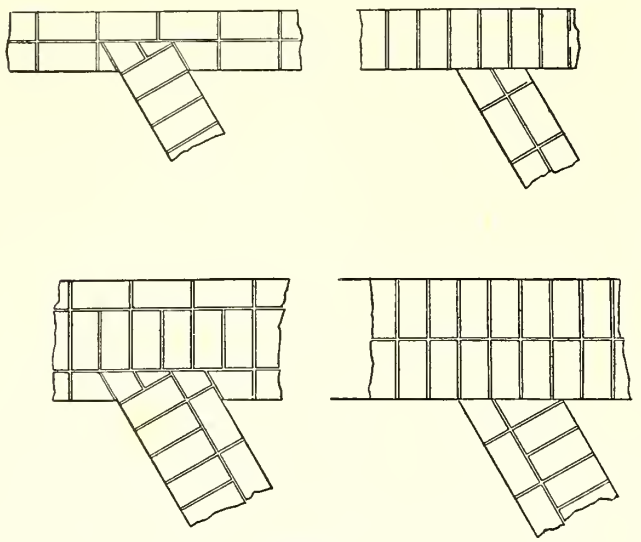
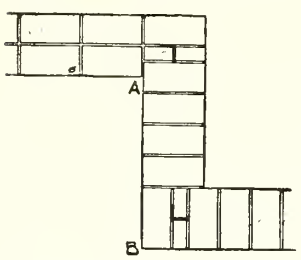


Fig. 94.

wall overlaps the main wall. A few of these oblique junctions are shown in Fig. 94.

Zed Junctions of Walls — Perhaps the simplest way to remember how to bond zed angles is to take them as three different cases.

1. Where the distance AB in Figs. 95, 96, and 97 = a multiple of half a brick plus a quarter of a brick.



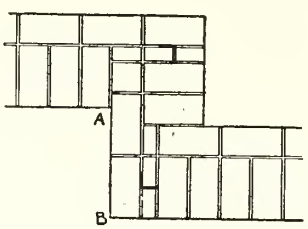
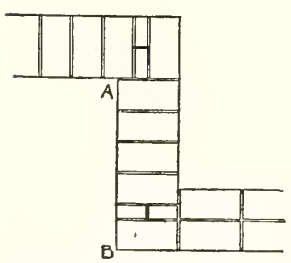


Fig. 95.



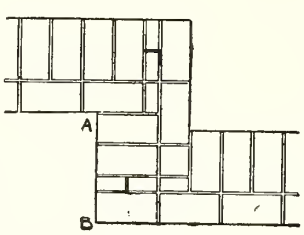
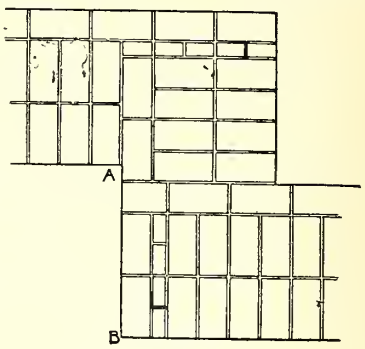


Fig. 96.

2. Where the distance AB as in Figs. 98 and 99 = a multiple of half a brick.

3. Where the distance AB as in Figs. 100 and 101 = a multiple of half a brick plus a distance which lies between a quarter and half of a brick, or which is less than a quarter-brick.

Case 1 is shown in Figs. 95 and 97, in which the distances AB are $[(5 \times 4\frac{1}{2}) + 2\frac{1}{4}]$ inches, and in Fig. 96 in which AB is equal to $[(3 \times 4\frac{1}{2}) + 2\frac{1}{4}]$ inches. In this case start to build the angles and prolong the small piece of wall between them and it will be found that it closes naturally. It will facilitate committing this to memory to notice that the directions of the closer at the angles form a right angle.



Case 2 is shown in Figs. 98 and 99, in which the distances AB are respectively $2 \times 4\frac{1}{2}$ inches and $6 \times 4\frac{1}{2}$ inches respectively. In this case an arrangement of bricks can be obtained giving a good bond, and it may be noted that the directions of the queen-closers are parallel to one another.

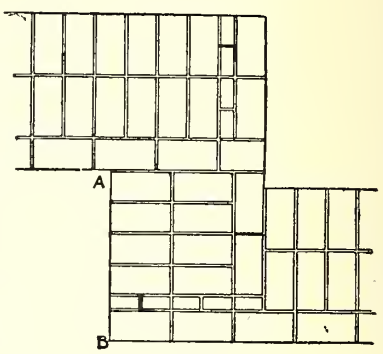


Fig. 97.

Case 3 is shown in Figs. 100 and 101, in which the distances AB are $[(4 \times 4\frac{1}{2}) + 3\frac{1}{2}]$ inches and $[(7 \times 4\frac{1}{2}) + 1\frac{1}{2}]$ inches respectively. This case presents most difficulty, and the bonding always needs to be specially devised, for after building up the angles and continuing the joining wall from these angles it is found that a gap of 4 inches in Fig. 101 remains in the middle to be filled up. This is done by inserting a brick cut to 4 inches in width in the course whose plan is shown on top in Fig. 101, while in the next course the bricks C, D, and E have to be cut to breakjoint with the courses above and below.

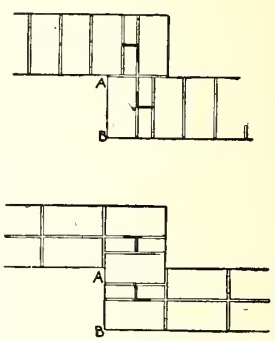


Fig. 98.

It may be noted here, again, that the queen-closers at the angles are at right angles to one another.

In Fig. 100 it has been found necessary to insert four bats to produce a satisfactory bond.

Squint Angles.—The principles of bonding enumerated in connection with right-angle junctions apply equally well to squint angles, except in the case of obtuse squints, when the closer next to the quoin-header is more often omitted, another expedient being employed to secure the necessary lap of a quarter of

a brick in the walls forming the angle. This will be explained in due course.

There are three other rules, the observance of which facilitates good bonding and economises labour.

1. Avoid small pieces of brick.
2. Avoid bird's-mouth cutting.
3. Avoid awkward cutting of any kind.

1. Small pieces will not overlap with the bricks in the courses above and below sufficiently to tie them together.

2. Some writers upon brickwork advocate bird's-mouth bricks for forming the internal angle of squints, on the plea that it gives the angle greater solidity; but as their application is limited to angles of not too pronounced acuteness, and as they are expensive to cut and no particular weakness has been observed in angles bonded without them, their use can only be considered to be a waste of labour.

3. Not only should the builder avoid bird's-mouth bricks, but also all bricks which entail an excessive amount of cutting. In fact, he should contrive to make all bricks of such a shape that they only need one cut with the trowel, or at the most two such cuts.

Acute Squints.—Fig. 102 shows the method of bonding acute angles. It is best in all cases to make a plan of the extreme corner bricks and determine the exact shape of the quoin brick, which should be accurately cut and the corner rounded as described later. To make this plan, draw two lines AB, BC (Fig. 102) representing the external angle of the walls. Along BA mark off the points D, E, and F,—BD being $4\frac{1}{2}$ inches, DE $2\frac{1}{4}$ inches, and EF $4\frac{1}{2}$ inches. Along BC mark off BG equal to 9 inches. Draw HK parallel to BC, and at a distance of $4\frac{1}{2}$ inches from BC. Draw EK at right angles to BA, cutting HK at K, join KD and draw GL at right angles to BC. This gives the exact shape BDKLG of the quoin brick, and as many of these should be cut as are required to form the angle to the specified height, *i.e.* two on each face per foot of height. As a preferable alternative, special bricks may be made of the shape BDKLG, one being wanted for each course, as they can be used upside down in alternate courses.

The shape of the closer will be found by the above diagram, but it will be noted that in the case of an angle of great acuteness this closer will be very small, and an arrangement such as is shown in the smaller drawing will give greater solidity to the corner; but in such cases specially made angle bricks are much to be preferred. The walls are then continued as shown, and it may be noted that the wall which shows headers on the external face overlaps, as it were, the wall which shows stretchers on its face, and it also abuts against these stretchers. A certain amount of cutting is necessary, and it should be done in such a manner as to produce large pieces of brick. In the two examples of acute squints shown in Fig. 102 it will be noted that, having drawn one course, the alternate course is obtained by tracing and reversing the first course as with right-angle junctions of walls.

Obtuse Squints.—In forming obtuse squints it is possible to do away entirely with closers next to the quoin-headers to secure the necessary lap of a quarter of

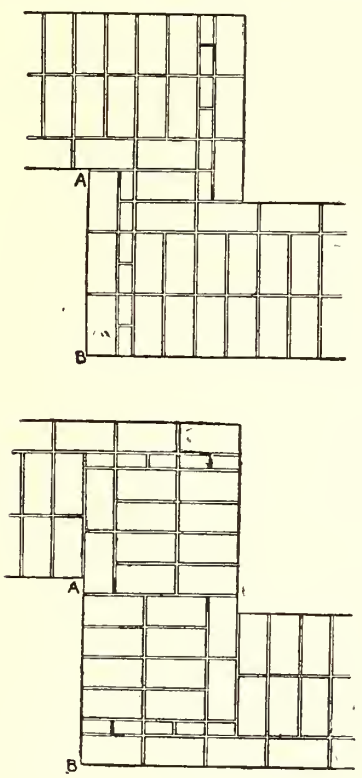


Fig. 99.

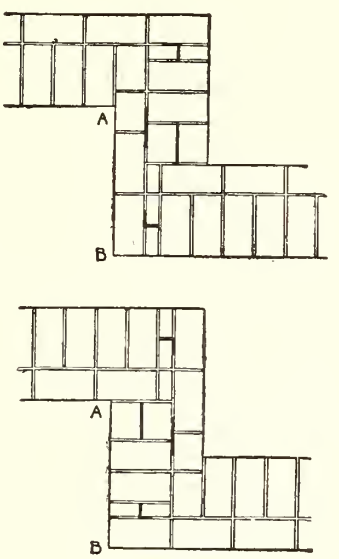


Fig. 100.

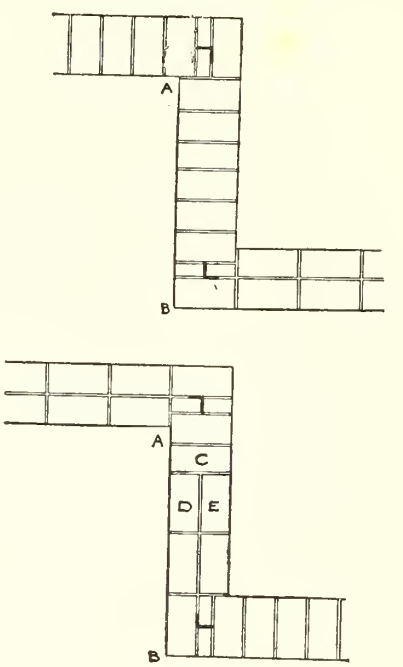


Fig. 101.

a brick, and instead single bricks may be cut with one face $2\frac{1}{4}$ inches larger than the other. Squints of any imaginable angle may occur in practice, being produced either by the shape of a site upon which a building is erected or by the fancy of the architect, and it is proposed here, as elsewhere throughout this work, to show a method which will apply directly or with only simple and obvious modifications to every possible case.

As with all angles it is usual to build them up from the quoin brick, the shape of this is first determined in the following manner.

Draw the plan of a brick ABCD (Fig. 103). From C mark off CE equal to $2\frac{1}{4}$ inches the amount of lap. Draw EF, cutting AD produced at F, and making the angle DEF equal to the angle of the squint minus a right angle —in this case 120 degrees has been chosen

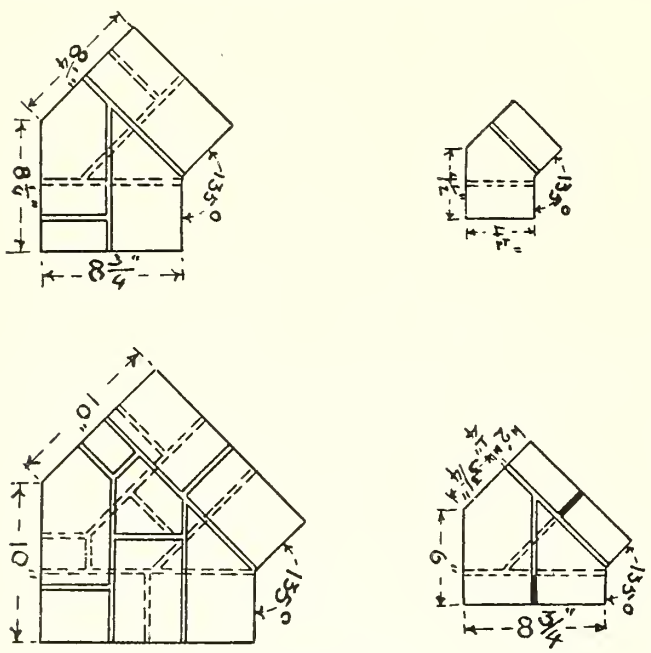


Fig. 105.

for the squint angle. Hence DEF = (120 degrees minus 90 degrees) = 30 degrees. Bisect the angle DFE by the straight line FG, cutting CD at G, and through G draw KGH at right angles to FE. From K draw KL at right angles to KG. Then BCGKL is the shape of the quoin brick for a squint of 120 degrees.

Fig. 103 also shows examples of obtuse squints formed by walls of various thicknesses meeting at various angles from 100 to 170 degrees, the shape of the quoins having been found by the above method. This method of finding the shape of the quoin brick holds good for all angles from just less than 180 to 112 degrees, in which last case the size of a brick limits the application of the method (see Fig. 104).

In squints of less than 112 degrees a different and even simple method is employed. The quoin brick is formed by splaying a whole brick from one corner to the required angle, as in Fig. 104. Measure AB, which in this case is $8\frac{1}{4}$ inches, subtract $2\frac{1}{4}$ inches, which leaves 6 inches, and place a closer next to the shorter face of the quoin brick, so that AC may be equal to 6 inches. The walls are then built from the corners as in right-angle junctions, and overlap one another in such a manner as to produce simple cutting with no small pieces of brick and no continuous vertical joints. There is no doubt that the reader will be able to devise other methods of fitting in the interiors of the walls at the angle, but those shown in Figs. 103 and 104 are of a very simple nature and comply with the principles of sound bonding, while they bear a great semblance to one another in their minor detail.

Of course, in the above examples the quoins should be carefully cut to the plan obtained by the method shown in Fig. 103 where neat work is required, while in rougher work a bricklayer will obtain a very near approximation to the correct shape by guess work.

Squint Piers with Plain Jambs.—In squint piers of small dimensions it is impossible to devise any universal system for bonding the bricks, but a particular method must be devised for each particular

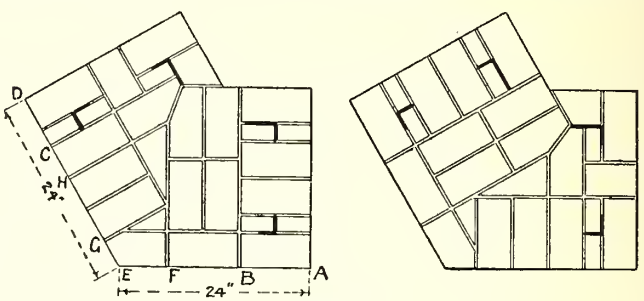


Fig. 106.

case. Fig. 105 shows examples of squint piers of dimensions likely to occur in practice.

A universal method of bonding squint piers of any dimensions is shown in Fig. 106, and the slight modifications, which are in some cases advisable, will be demonstrated afterwards. It is supposed in Fig. 106 that the outline plan has been taken off a plan. The method of procedure is as follows: Lay the stopped ends first of all, and then starting from the stopped ends lay the external facing bricks until there is room for no more. A space is left at the corner, and to fill this a brick is taken, and along one of its faces the distance EF is measured; the brick is splayed from the point E to the required angle, and the brick cut to fit the space left. The rest of the wall is then filled up according to the rules already demonstrated, thus completing one course. The next course is the same as the first, viewed through the back of the paper upon which it is printed.

The question which naturally arises at this point is, Why does this method give a satisfactory lap? The reason is a simple one. The differences between the

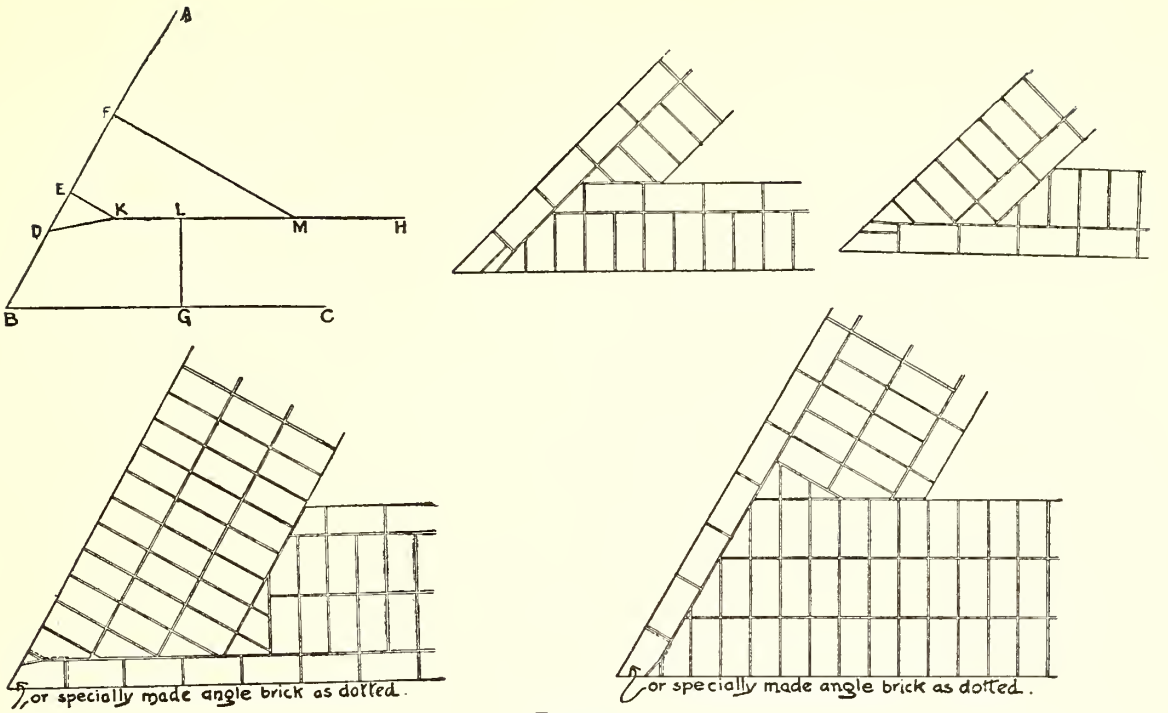


FIG. 102.

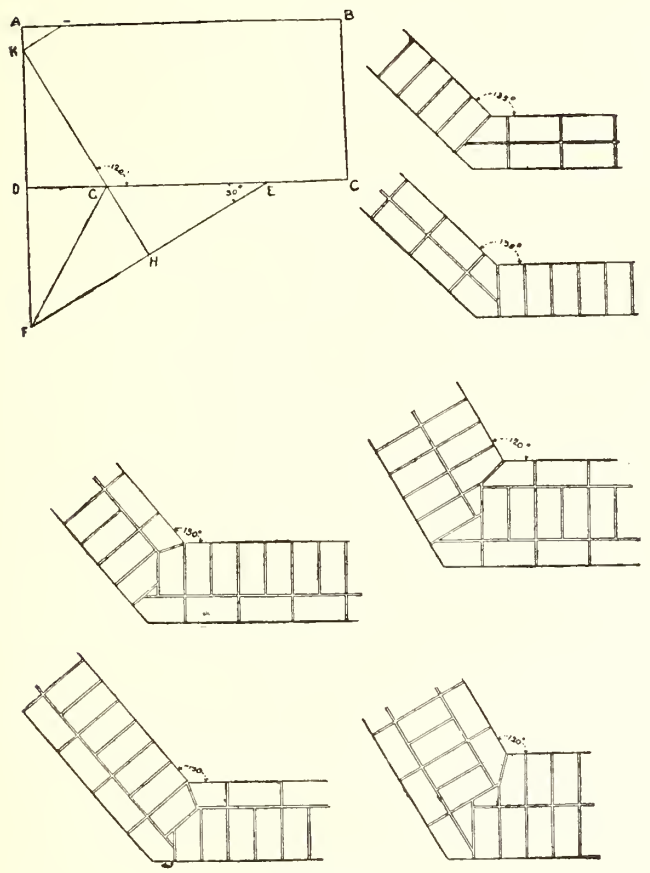


FIG. 103.

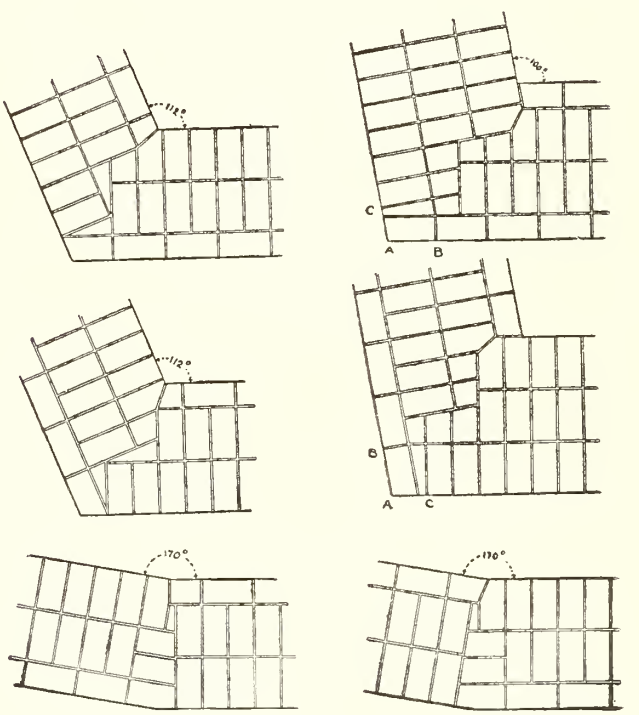


FIG. 104.

distances EF and EG, EB and EH, etc., are always equal to $2\frac{1}{4}$ inches, because the difference between AB and DC is $2\frac{1}{4}$ inches. It is quite possible to have a pier of such dimensions as to necessitate making the quoin brick very small, when the brick should be shaped as in Fig. 107 in order to make the angle more solid. It is better, however, to make the quoin brick

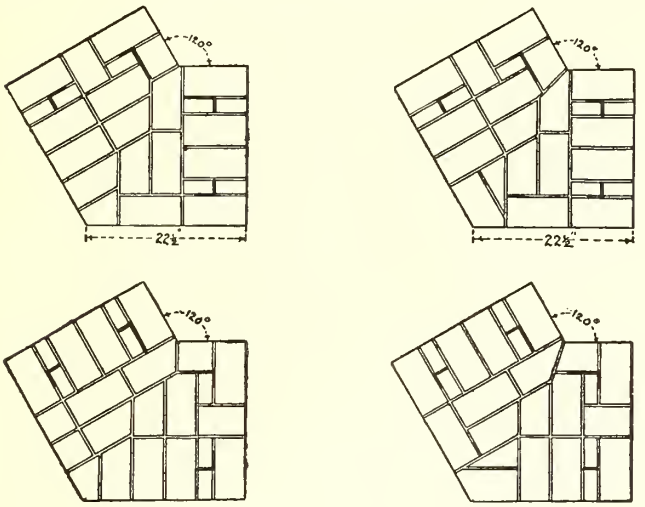


Fig. 107. Fig. 108.

as large as possible, and this can be done by laying the quoin along the other face of the pier, as shown in Fig. 108.

Squint Piers with Rebated Jambs.—Small squint piers with rebated jambs must be devised for each

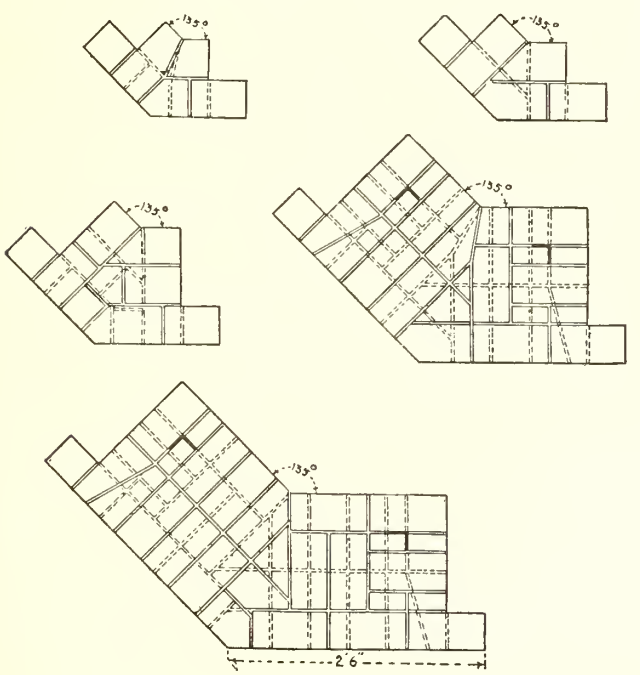


Fig. 109.

particular case, as shown in Fig. 109, but larger ones may be formed on the same system as squint piers with plain jambs. The jambs being laid first, the facings are then filled in, and the quoin cut to fit. The interior is then filled with headers and the smallest possible number of the largest possible pieces. Figs.

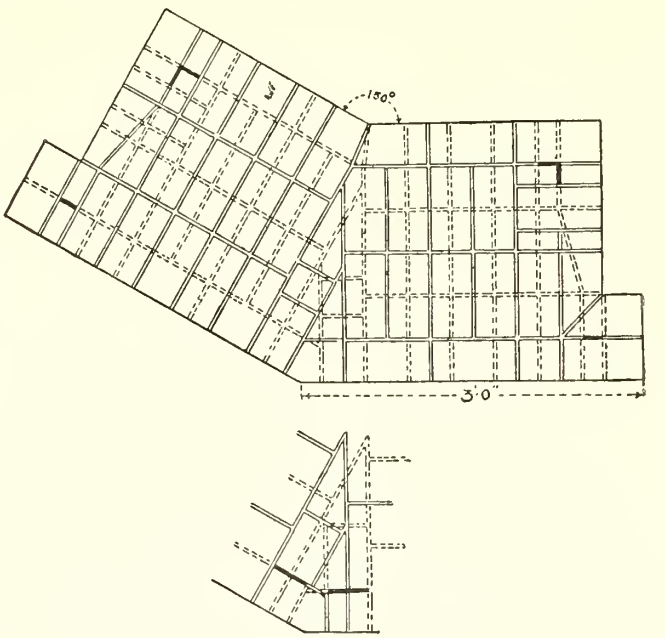


Fig. 110.

109, 110, and 111 show examples of piers formed on this system, Fig. 111 having splayed internal jambs.

In Fig. 110 the quoin is rather small, and an expedient sometimes resorted to to remedy this defect is shown in the lower drawing, which illustrates the arrangements of bricks round the external angle. The closer may

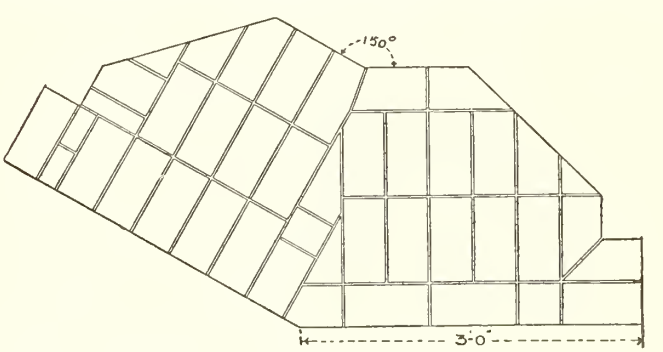


Fig. 111.

be of any size, so long as it is neither small enough to need a quoin brick more than 9 inches long nor large enough to make the quoin brick too small.

English Cross Bond is a variety of English bond in which the stretching course breaks joint with the alternate stretching courses, as well as with the heading courses. It is formed in two ways. First, by inserting a header next to the quoin stretcher in every other stretching course, as shown in Fig. 112; and secondly, by dispensing with closers and using three-

quarter bats as quoins in all the stretching courses and headers next to these quoins in every other stretching course, as in Fig. 113. Its name is derived from the appearance of its facings, which appear to be composed of a number of crosses interlocking with one another, as shown by the shaded portions in Figs. 112 and 113.

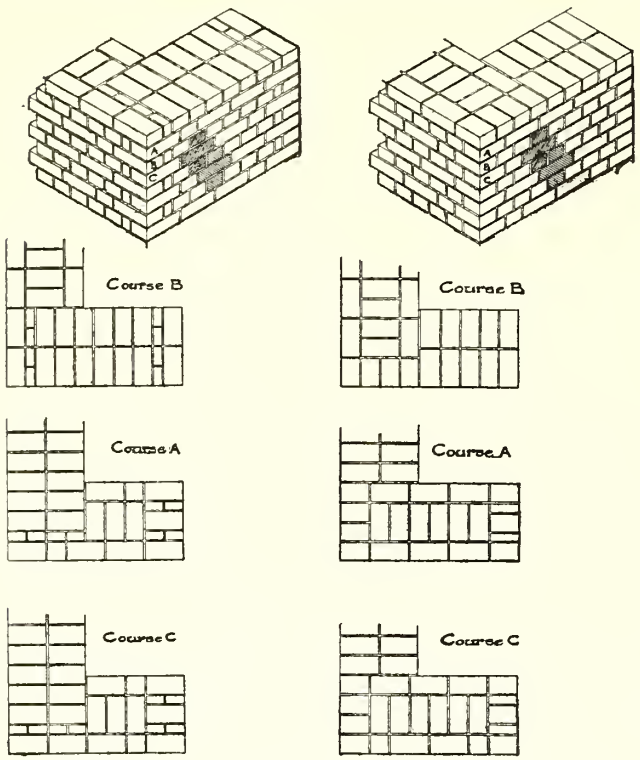


Fig. 112. Fig. 113.

The variety of English cross bond shown in Fig. 113 is very much used in Holland, for which reason it is also known as *Dutch Bond*.

Raking Bond.—The longitudinal strength of a thick wall is small in proportion to that of a thin wall, on account of the large proportion of headers used in the interior of the latter, and for the same reason the transverse strength of a thick wall is large in proportion to that of a thin wall. Hence it follows that the thicker a wall is the greater is the difference between so transverse and longitudinal strength, and it therefore becomes necessary to strengthen thick walls longitudinally. This is done by means of *Raking Bond*, of which there are two kinds—*Diagonal Bond* and *Herring-Bone Bond*.

Diagonal Bond is the name applied to courses of brickwork which have the facings laid in the ordinary manner, but have the interiors filled up with bricks laid diagonally across the wall, as in Figs. 114 and 115. This form of bond is used on walls from 2 to 4 bricks thick. Fig. 115 shows one course of diagonal brickwork in a $3\frac{1}{2}$-brick wall, the mode of building which is as follows: Lay the facings and fill up the angle as in ordinary English bond. Next place the brick A with the corners *a* and *b* touching the facings, and with its sides forming an angle of about 31 degrees with the two adjacent faces of the wall. The bricks B and C

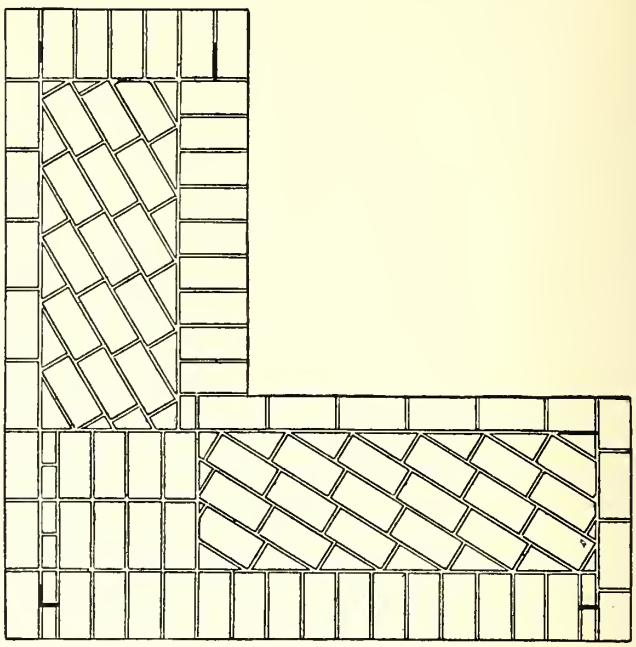


Fig. 114.

are then placed end to end with A, and adjusted to a straight line, and the corners *a*, *b*, and *c* made to touch the facings. The rest of the course is then filled in as

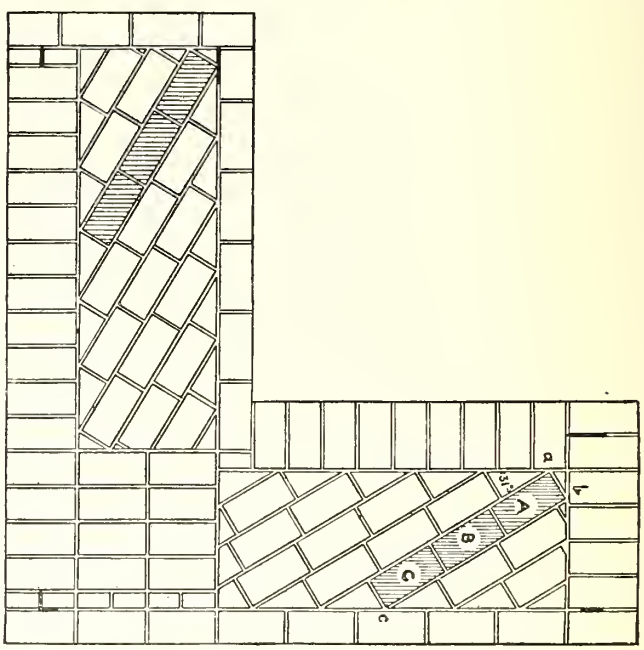


Fig. 115.

shown. This method gives a maximum number of whole bricks in the interior of the course with the minimum amount of cutting. The diagonal work is sometimes carried round the angle, but this involves

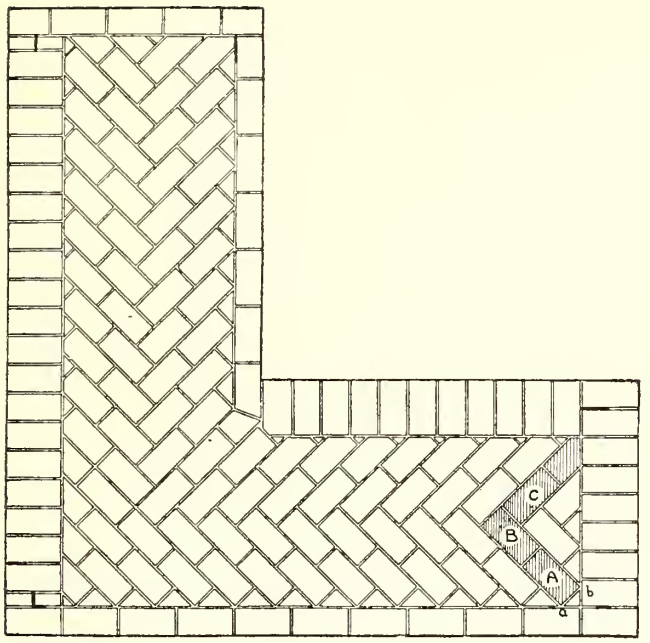
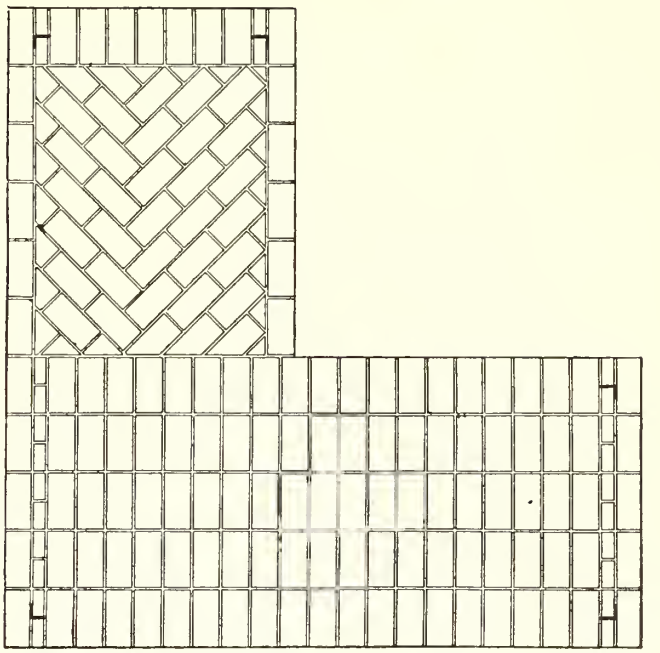
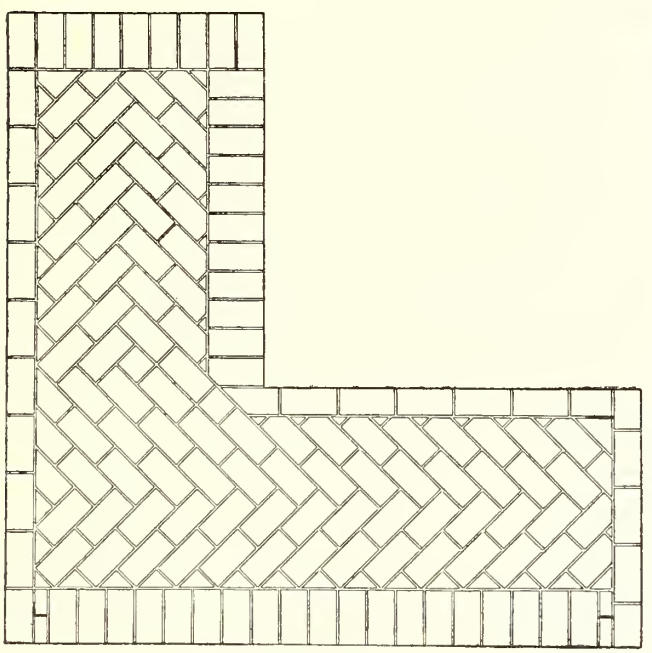


FIG. 116.





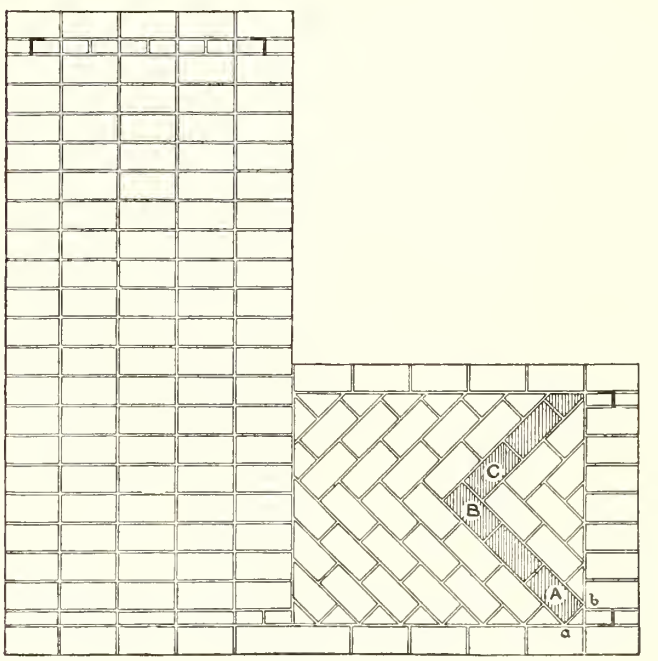


FIG. 117.

a large amount of cutting. The other wing is filled up in precisely the same manner.

Fig. 114 shows the diagonal work sloping in the opposite direction. A course of diagonal work is built into the wall at intervals of from three to eight courses. Suppose it is decided to build a 3½-brick wall with diagonal courses at intervals of five courses. Then four courses of ordinary brickwork will be built; then one course as in Fig. 114; then four more courses of ordinary brickwork, and then one course as in Fig. 115; and so on.

It is better to have an even number of courses between the diagonal courses in walls of an odd number of half-bricks in thickness, as this arrangement increases the bonding effect of the diagonally laid bricks, as will be seen by superimposing a tracing of Fig. 114 over Fig. 115.

When a wall is of an even number of half-bricks in thickness the arrangement is somewhat different. The facings are laid as before, and the angle and the whole of the heading course is filled up with headers as in ordinary brickwork. The stretching course is filled up with bricks laid diagonally and in the manner already explained, the shaded portions in Figs. 118 and 119 corresponding with the shaded portions in Figs. 114 and 115. An even number of courses of ordinary brickwork should come between the courses of diagonal work, so that a wall will be built up as follows: One course as in Fig. 118; one course as in Fig. 119; an even number of courses of ordinary brickwork; one course similar to Fig. 118, but with the diagonal bricks sloping in the opposite direction; one course similar to Fig. 119, with the diagonal bricks sloping in the opposite direction; and so on.

The diagonal work is used in one wing only of any course, as it is undesirable that it should occur in the heading course. Such an arrangement would decrease the area of the diagonal work, and consequently decrease the longitudinal strength of the wall.

Herring-Bone Bond.—This form of bond is used for the same purpose as diagonal bond in walls three bricks thick and upwards, but is most commonly used for walls over four bricks thick. The facings are laid in the usual manner, and the interior of the herring-boned course is filled up with bricks laid as shown in Figs. 116 and 117, the method of procedure being as follows: Lay the brick A (Figs. 116 and 117) with the corners *a* and *b* on the facings, and with its sides at 45 degrees to the faces of the wall. Lay bricks end to end with A until the last brick B reaches the centre of the wall as nearly as possible. Next lay the brick C at right angles to B, and lay other bricks end to end with C until the facing bricks are reached, the last brick laid being cut to fit if necessary. The rest of the work is then filled up, as shown in Figs. 116 and 117, whole bricks being used against the facing bricks to correspond with A.

In walls of an odd number of half-bricks the herring-bone work may be carried round the angle as shown in Fig. 116, but in walls of an even number of half-bricks

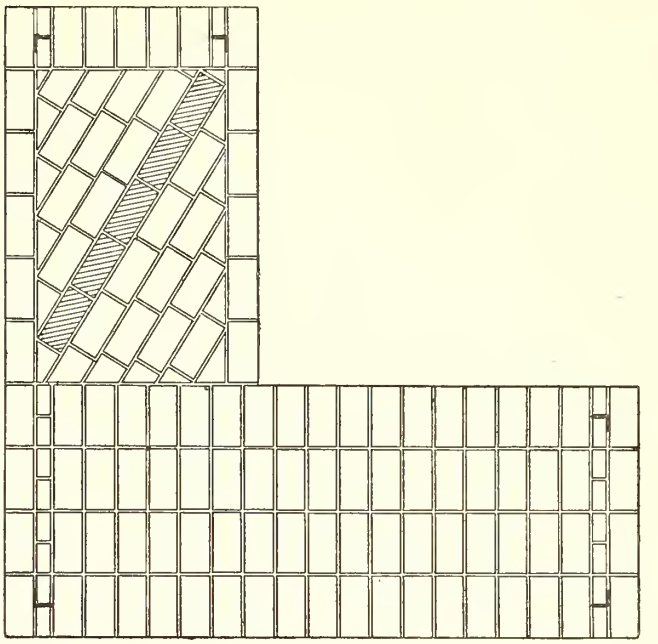


Fig. 118.

the angle and the heading course should be filled in with headers in the usual manner, and the stretching course filled with herring-bone work, as in Fig. 117.

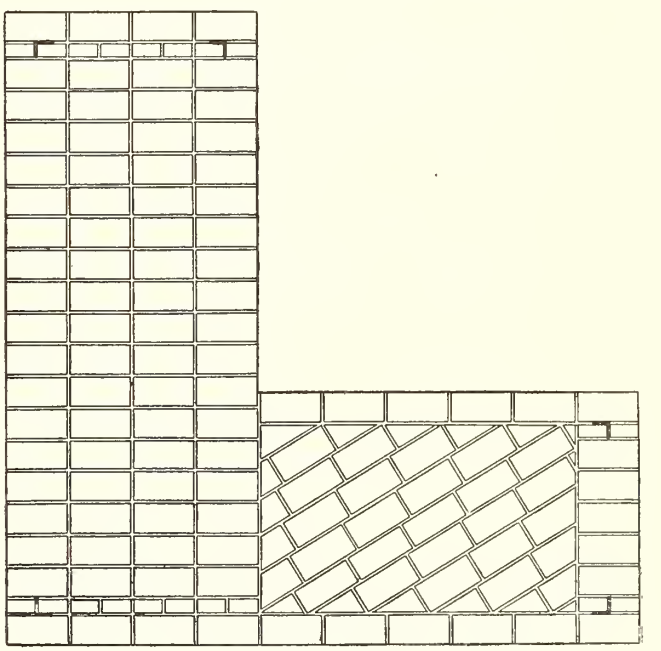


Fig. 119.

The remarks made above with regard to the vertical spacing of the diagonal courses applies equally well to the spacing of herring-bone courses; and in alternate

courses of herring-bone work the direction of the bricks is reversed.

Raking bonds are only used in connection with English bond, as a large amount of cutting would be required to fit the diagonal bricks into Flemish facing.

Hoop Iron Bond.—A good method—increasing the longitudinal strength of brick walls built in any kind of bond—is by building in rows of hoop iron, 1 by $\frac{1}{16}$ inch, at intervals between the courses, as shown in Fig. 120, in the direction of its length, one row being used for each half-brick in the thickness of the wall. The iron should be thoroughly tarred and sanded before use in order to prevent oxidation. The methods of joining lengths of hoop and of forming angles therein are shown at A and B, Fig. 120, respectively.

Hoop iron may be used with advantage when great strength is required, or when it is impossible to obtain a satisfactory bond by the overlapping of the bricks; but as iron expands when exposed to heat, this construction is not to be recommended in a building which is intended to be fire resisting.

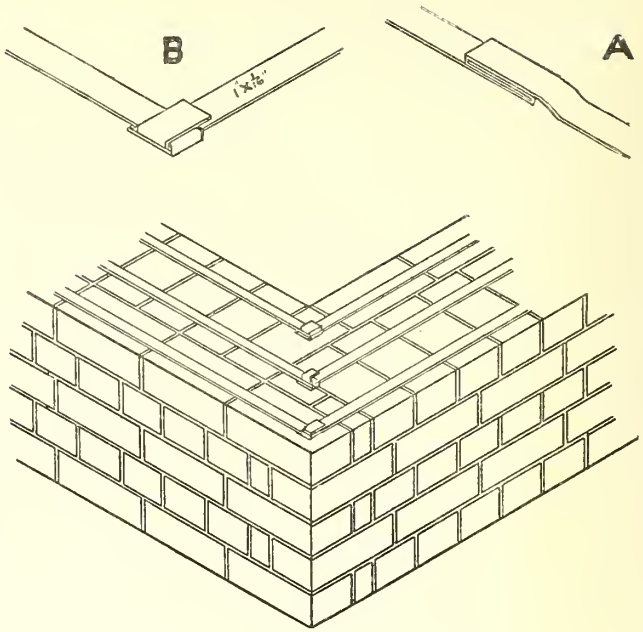


Fig. 120.

CHAPTER IV

FLEMISH BOND, DOUBLE AND SINGLE; HEADING BOND; STRETCHING BOND, AND GARDEN-WALL BOND

Double Flemish Bond.—The appearance of double Flemish bond is shown in Fig. 121, in which it will be seen that in each course headers and stretchers alternate, the face of the headers coming centrally above the faces of the stretchers in the course below. As in English bond, the lap is produced by placing a queen-closer next to the quoin-header in every course. This system of bonding is much weaker than English bond, on account of the large proportion of vertical joints—blackened in Figs. 122, and, in the case of walls of an odd number of half-bricks in thickness, of the small proportion of headers generally used in their interiors. The advantages of Flemish bond are, that it is economical when expensive facing bricks are used, as it only requires 64 headers per square yard when all are whole bricks, against 72 per square yard required for English bond; that walls one brick in thickness are easier to produce a fair face on both sides in Flemish than in English bond; and that, in the opinion of many, the appearance of Flemish bond is preferable to that of English bond.

Rules for Double Flemish Bond.—Besides the

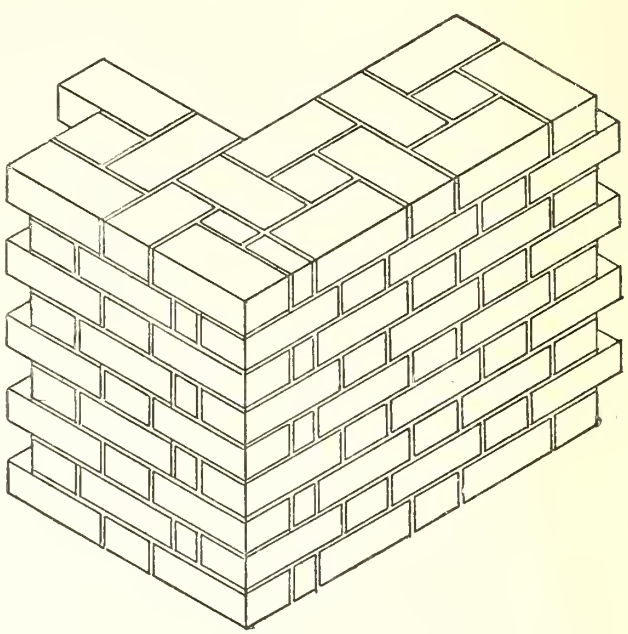


Fig. 121.

general rules given on page 66, there are several others which apply particularly to double Flemish bond:—

1. There should always be a quoin-header in every other course.

2. There should always be a queen-closer next to the quoin-header, which is broken at 1-brick intervals through the whole thickness of the wall.

3. Each course should consist of headers and stretchers alternately.

4. Except in 3-half-brick walls, the headers and stretchers on one face of the wall should be respectively opposite headers and stretchers on the other face of the wall in the same course.

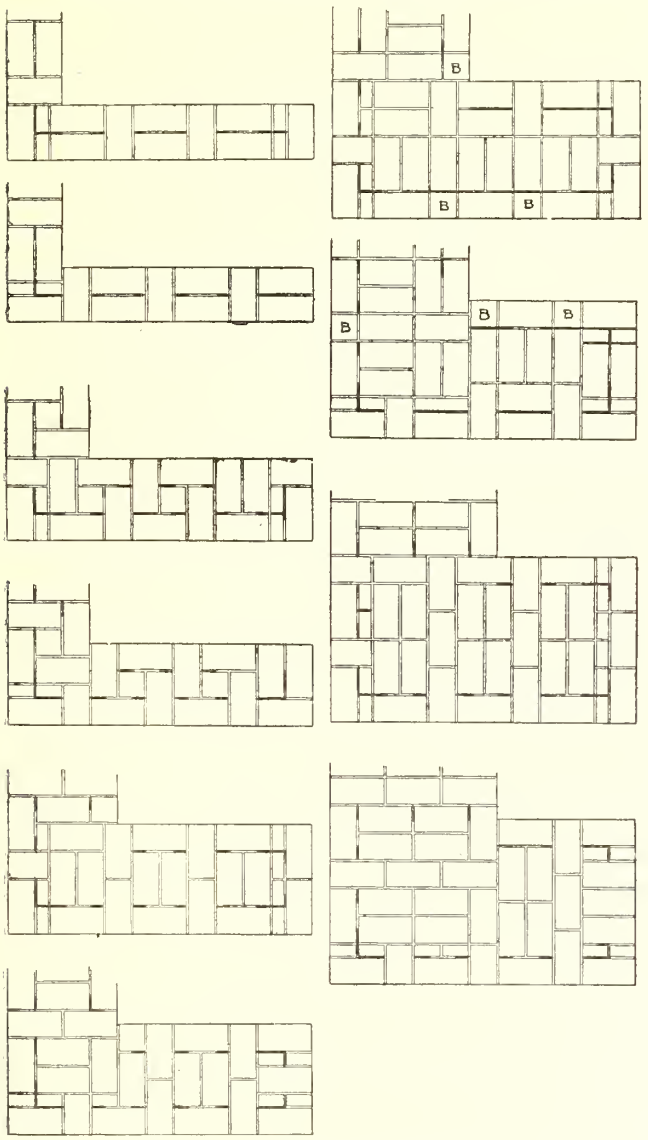


Fig. 122.—Double Flemish Bond.

It will be noticed that in walls of an odd number of bricks in thickness a considerable number of half-bats occur, while the proportion of headers in the interior of the walls is small; and in the case of walls of 5, 7, etc. half-bricks thick the proportion of continuous vertical joints is double that occurring in walls of an even number of half-bricks in thickness. In spite of this defect, 2½-brick walls are usually built as in Fig. 122, unless specified otherwise, on account of the economy in facing bricks, only 56 per square yard being required, as two of the half-bats or *false headers* are formed by cutting one facing brick in half. The remedy for this defect is to make the bricks B,B,B (see Fig. 122) three-quarter bats, as well as those immediately behind them.

Single Flemish Bond is a species of bond in which the face of the walls shows alternate headers and stretchers in each course as in double Flemish bond, while the rest of the wall is built in English bond. It is used when the appearance of the former and the strength of the latter are required.

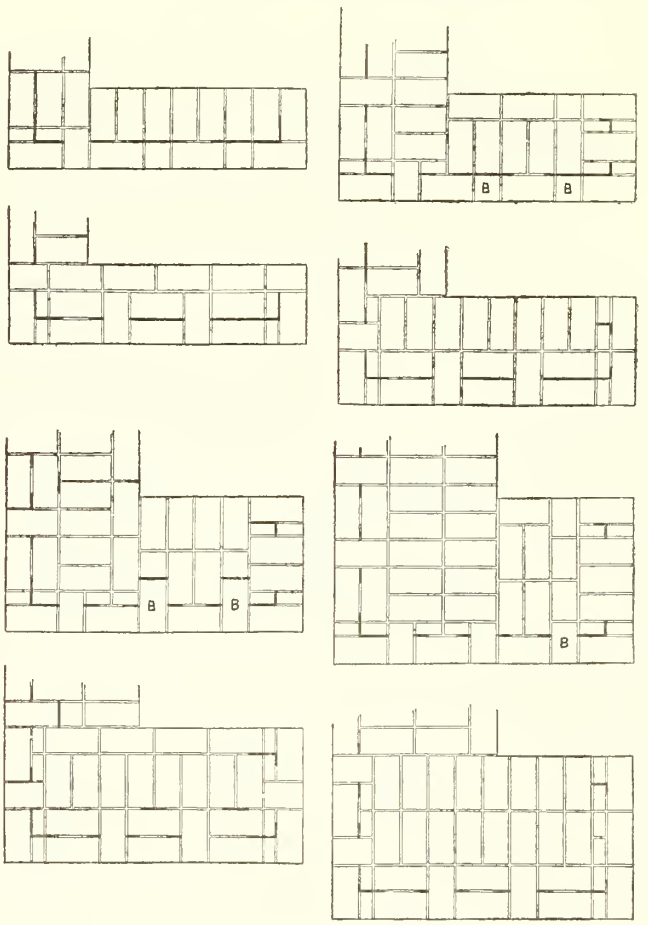


Fig. 123.—Single Flemish Bond.

In building walls in this bond the external facings are first laid as in Flemish bond and the internal facings are laid as in the bonding diagram in Fig. 84, while the interior of the wall is filled in with as many headers as possible. Alternate courses of walls from 1½ to 3 bricks thick are shown in Fig. 123. It will be

seen that this system cannot be employed in walls of less than 1½ bricks thick.

The stopped ends may be formed as in English or double Flemish bond, but it is customary to employ the former.

When expensive facing bricks are used, the bricks B,B,B (Fig. 123) are frequently made false headers for the reasons already explained, but where maximum strength is required they should be made whole or three-quarter brick as the exigencies of the case require, and the sizes of the adjacent bricks are altered accordingly.

Plain Jambs are bonded in precisely the same manner as stopped ends, those in double Flemish bond being shown in Figs. 122, while those in single Flemish bond are shown in Fig. 123, and it will be noted that in the latter case the system is the same as that employed in English bond.

Rebated Jambs.—The method of forming 2¼-inch reveals in double Flemish bond is shown in Fig. 124.

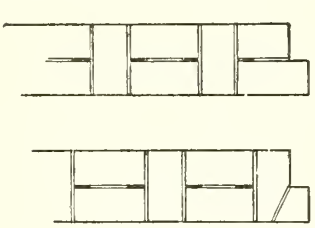


Fig. 124

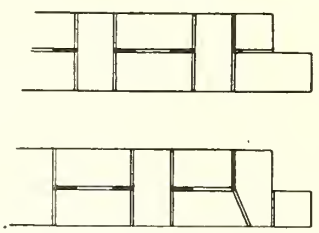


Fig. 125.

Examples of rebated jambs in double Flemish bond with 4½-inch reveals are shown in Figs. 125 and 126, and those with 9-inch reveals are shown in Fig. 127.

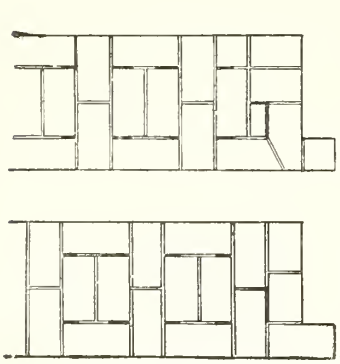


Fig. 126.

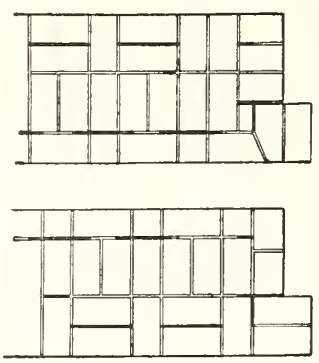


Fig. 127.

Exactly the same system has been followed in each case, and can be followed in every other case.

Square Piers.—It is impossible to give to a 1-brick pier the characteristic appearance of Flemish bond, so they are always bonded in English bond. Larger piers are bonded as shown in Fig. 128. When an isolated square pier is built near other brickwork in single Flemish bond it should be bonded as shown in Fig. 128, as it is only its appearance which has to be considered.

Right-Angle Junctions of Cross Walls are formed by letting one course of the cross wall into the main

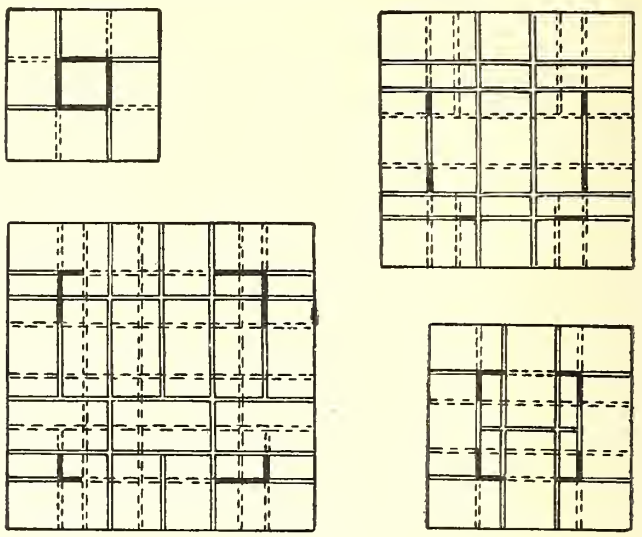


Fig. 128.

wall, and butting the next course of the cross wall against the main wall, in a similar manner to that shown for English bond, save that three-quarter bats take the place of queen-closers, as shown in Fig. 129.

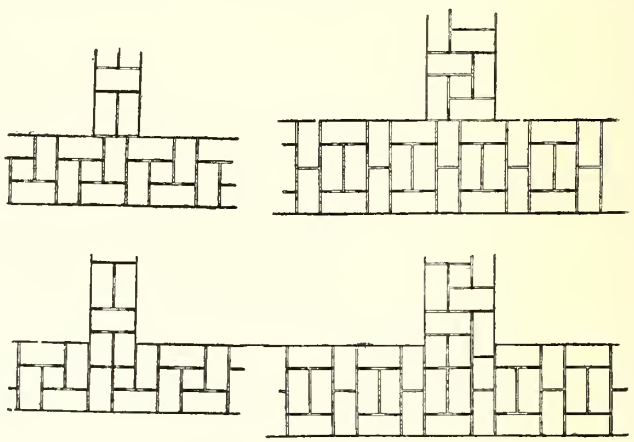


Fig. 129.

When cross walls are to be plastered there is no object in bonding them in Flemish bond, as appearance is then of no consequence, and strength is sacrificed by doing so.

Cross Walls at Various Angles.—An example of the junction of a cross wall in double Flemish bond is shown in Fig. 130, which it will be noticed is only a slight modification of the second case in Fig. 129.

In Acute Squints.—The quoin brick is first cut, as already explained in the previous Chapter, and placed in position. The facings are then laid, and the interior of the wall filled up as shown in Figs. 131 and 132. In the Flemish bonds it is often impossible to prevent the occurrence of small pieces, and when this is the case the

angle should be built in cement, or a special angle brick should be made.

Obtuse Squints.—In these the quoin brick is shaped

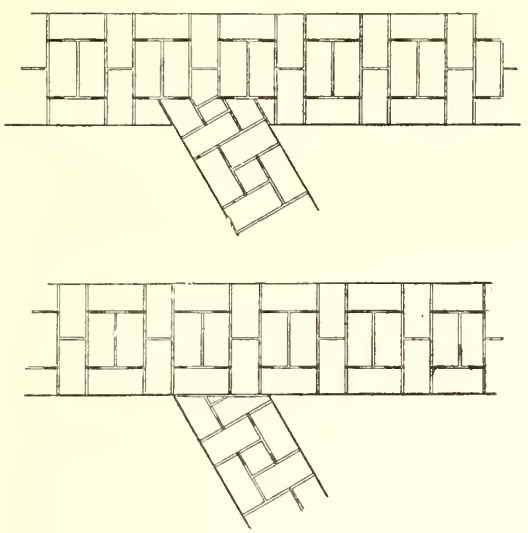


Fig. 130

as explained with regard to English bond, and is laid first. The facings are then built on and the interior of the wall filled in. In angles of less than 112 degrees a closer must be used next to the quoin-header, for the reason already explained. Examples of these are shown in Figs. 133 and 134.

Squint Piers with Plain Jambs.—When squint piers are of small dimensions no definite system can be followed in bonding them, but they must be specially devised in each case. When the dimensions are comparatively large the universal method already explained

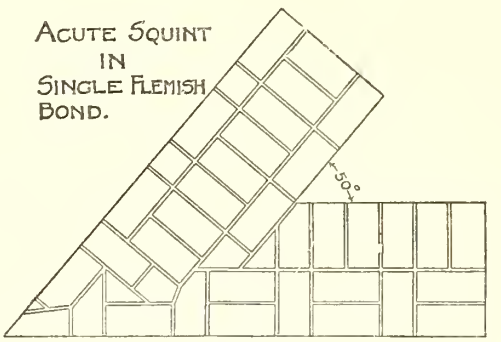


Fig. 132.

may be used, as shown in Figs. 135 and 136. It will be noticed that in one example in Fig. 135 a closer has been used in order to prevent a joint coinciding with the external angle.

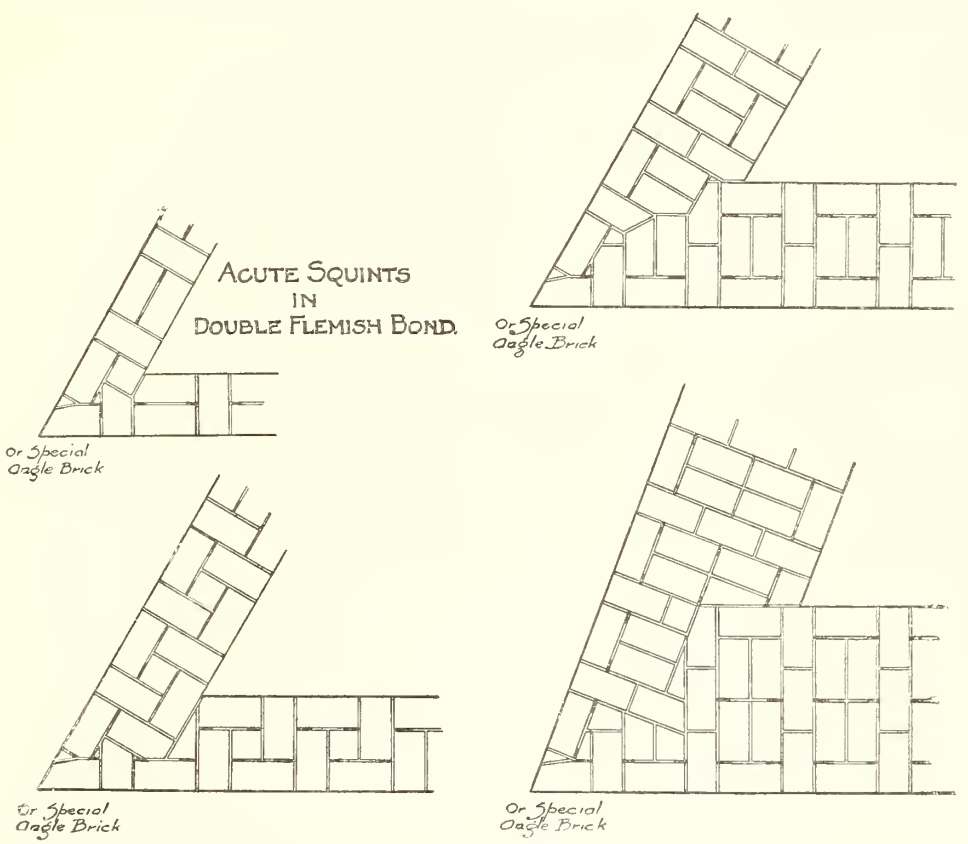


Fig. 131.

Squint Piers with Rebated Jambs.—Small piers with rebated jambs have to be devised for each particular

case, but when their dimensions are large the system already explained may be employed as shown in Figs. 137 and 138. A closer is shown at the angle of one

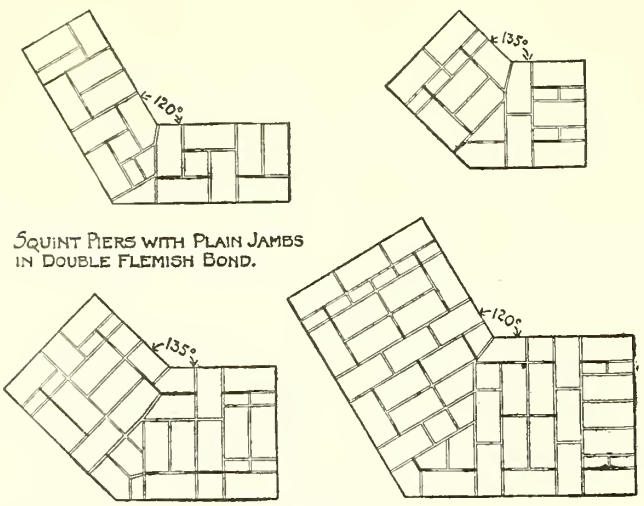
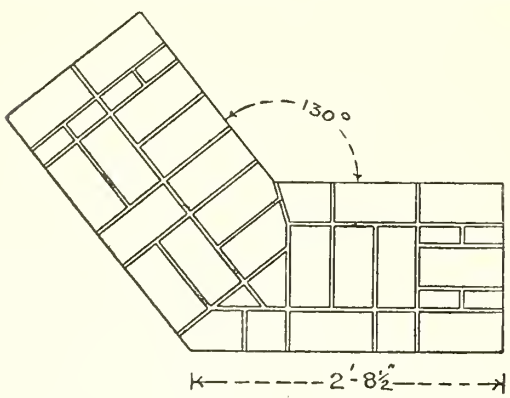


FIG. 135.

example in Fig. 138, to prevent a joint from occurring too near the angle.

HEADING, OR HEADER BOND—as it is sometimes called



SQUINT PIERS WITH PLAIN JAMBS IN SINGLE FLEMISH BOND.

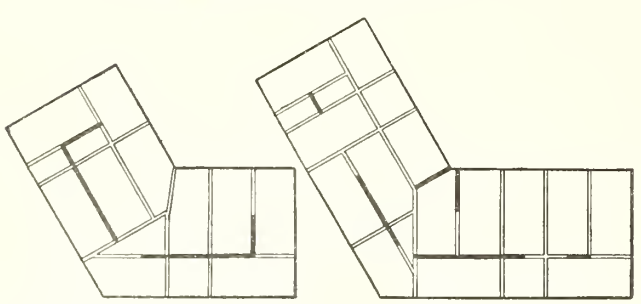


FIG. 136.

—is the name applied to a description of bond in which all the bricks are laid on headers. It is used for working round *quick sweeps*, as in Fig. 139. If stretchers be used for the purpose the curve has a broken appearance. This form of bond should never be used in straight

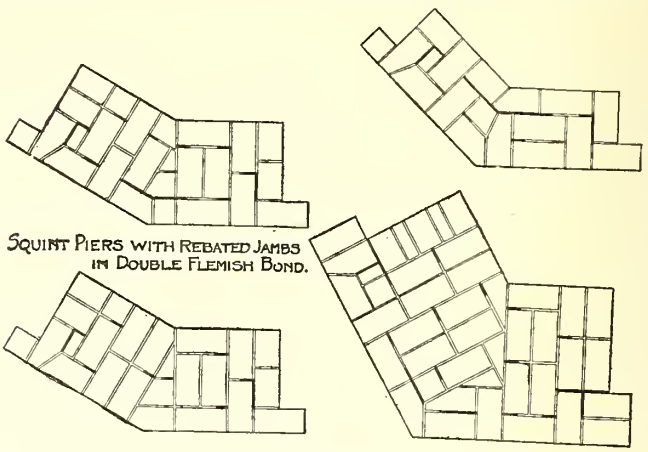


FIG. 137.

work, as it is very weak, particularly in walls of an odd number of half-bricks in thickness, as it necessitates the use of half-bats.

STRETCHING, OR STRETCHER BOND, is a description in which all the bricks are laid in stretchers, as in Fig. 140.

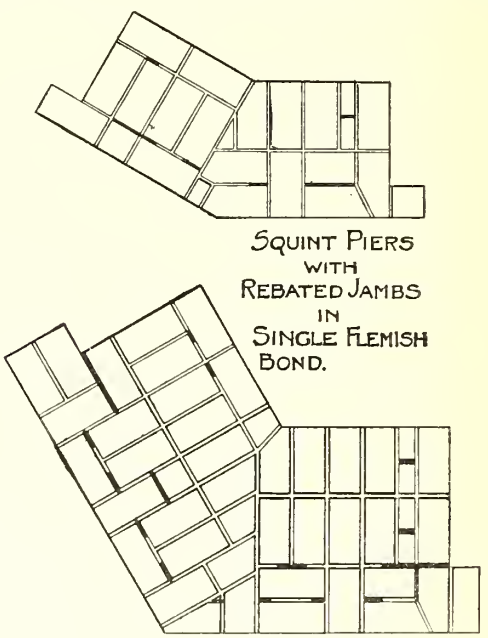
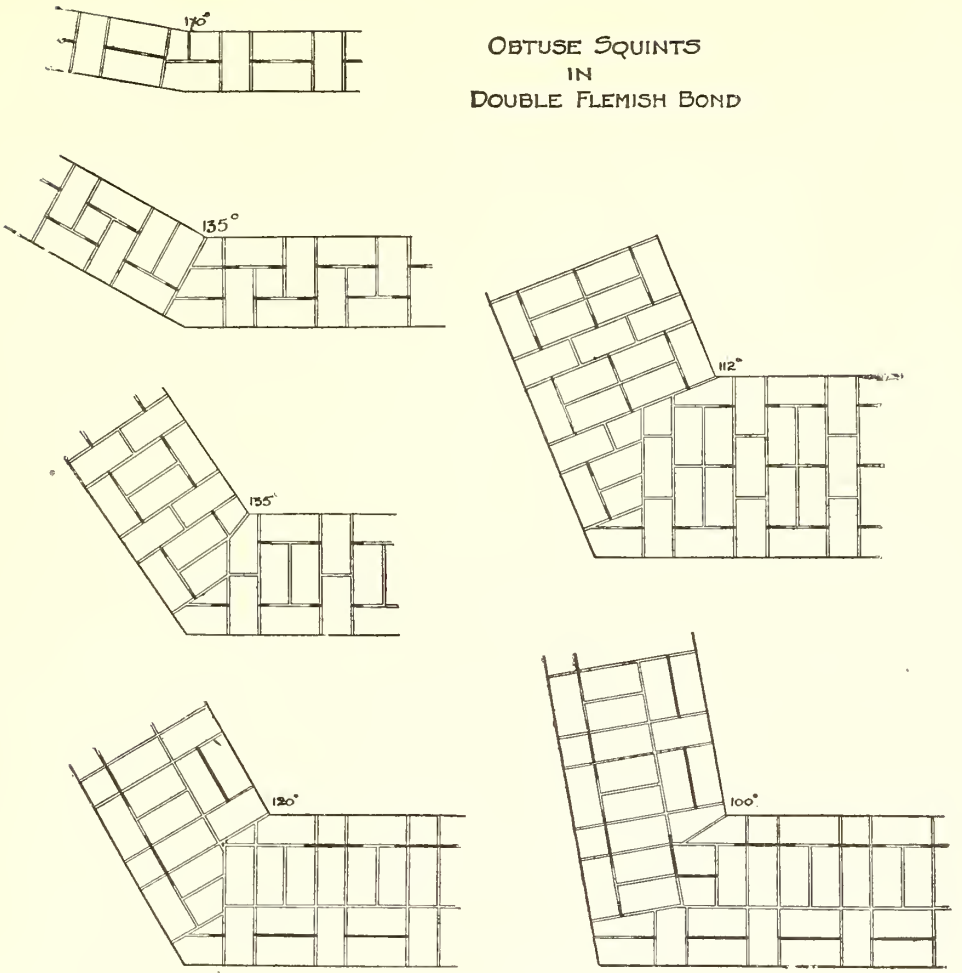


FIG. 138.

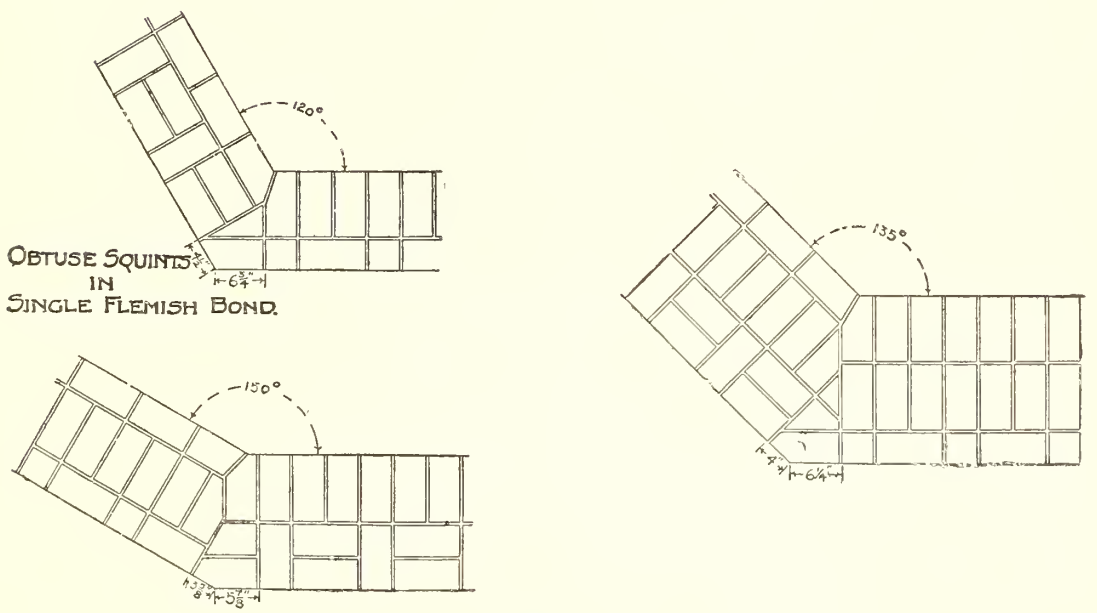
It is only used in walls of half-brick in thickness, such as partitions, the outer skins of cavity walls and walls to flues. It is due to its constant occurrence in the last position that the name *Chimney Bond* is frequently applied to it.

GARDEN-WALL BOND is the name given to a description of bond much used for 9-inch walls when a fair face is required on both sides. The name is sometimes applied to a wall composed of three or four courses of stretchers alternating with one of headers, as in Fig. 141,



OBTUSE SQUINTS
IN
DOUBLE FLEMISH BOND

FIG. 133.



OBTUSE SQUINTS
IN
SINGLE FLEMISH BOND.

FIG. 134.

but this variety of bond is more generally known as *Facing Bond.* In some localities the term garden bond

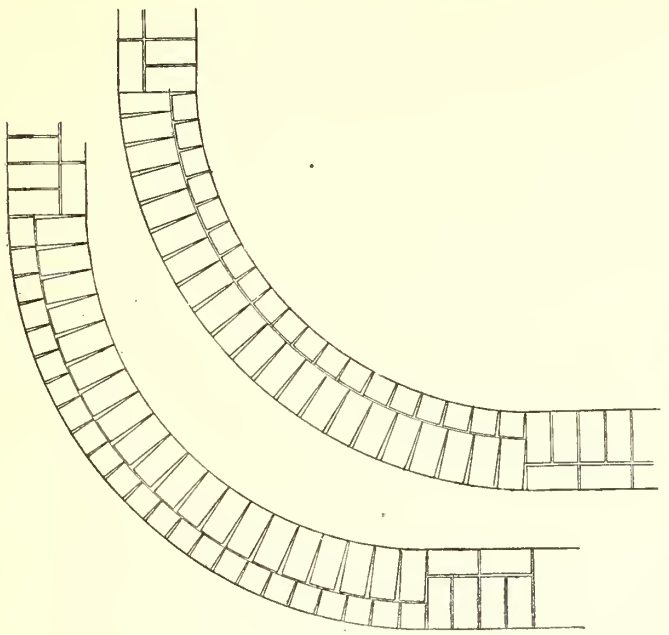


FIG. 139.

is applied to walls built so as to show three stretchers and one header in each course, as in Fig. 142.

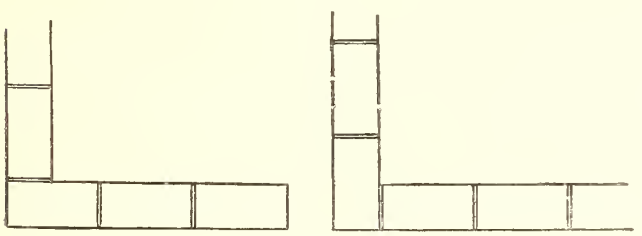


FIG. 140.

It is very difficult to build walls with a fair face each side in English or Flemish bond with ordinary bricks, as they vary considerably in length. When the number of headers is reduced they can be picked to an even length or cut if necessary.

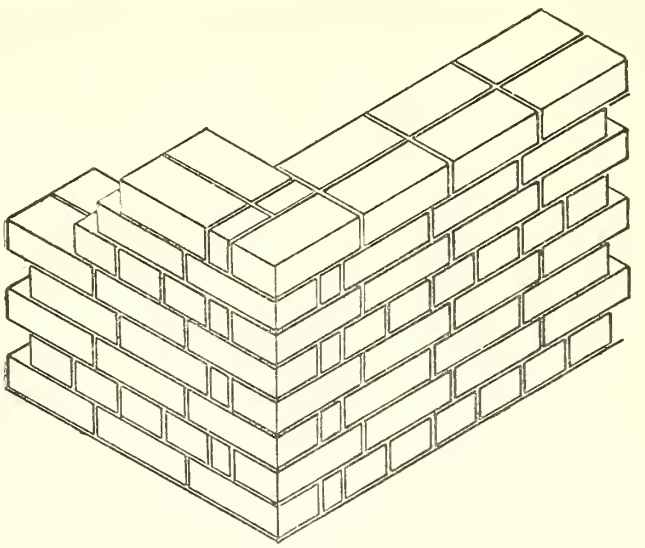


FIG. 141.

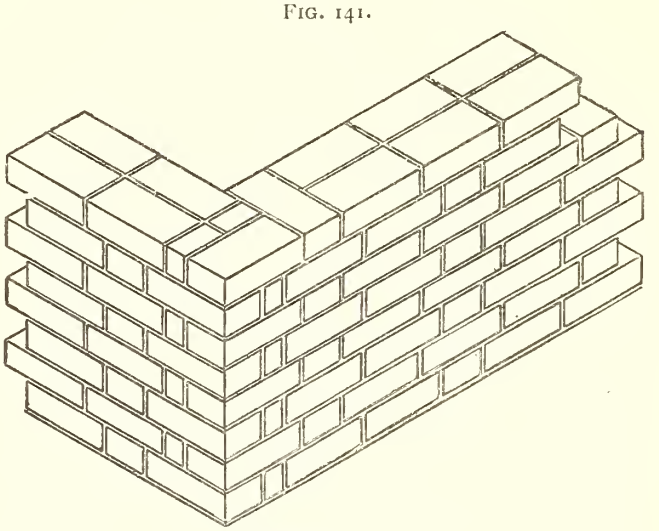


FIG. 142.

The terms *Boundary Wall, Sussex, Scotch, and Common Bond* are local names for garden-wall bond.

CHAPTER V

FOOTINGS, COPINGS, CORNICES, CORBELS, DAMP-PROOF COURSES, HOLLOW WALLS

Footings.—As walls usually carry greater loads than would be safely borne by the same area of the soil upon which they rest, they are spread out at their base by projecting the courses in off sets of a quarter of a brick until the desired width is obtained, as shown in Fig. 143. These projecting courses are called *Footings*, and it is usual to make the width of the lower course equal to twice the width of the wall above—that is to say, the number of courses on the footings is equal to the number of half-bricks in the thickness of the wall. All the external bricks of the footings should be laid as headers, so that they may tail well into the wall. The lowest course of footings rests upon a block of concrete, the width and depth of which is determined as explained in Chapter I.

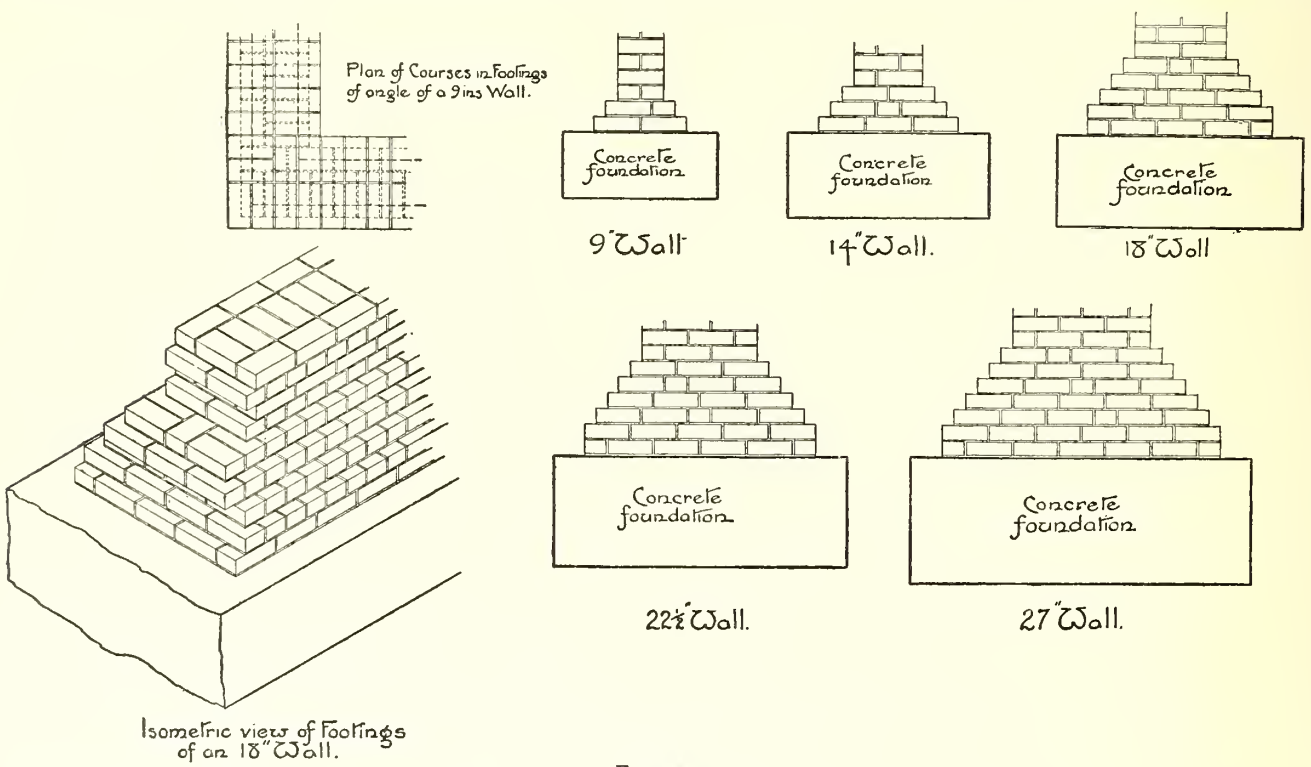


Fig. 143.

In walls of two or more bricks in thickness the lowest course of footings is generally laid double, while in very thick walls, particularly when they carry heavy loads, each course of footings should be double.

Instances of these double lower courses are given in Fig. 143.

Copings, or the topmost coverings of walls, are used for the purpose of preventing rain water from soaking down into the walls. They are very often formed of bricks laid on their edges across the wall, those of a highly vitrified nature being most suitable for the purpose. They afford greater protection if they project beyond the faces of the wall, thus throwing off the water, and for this purpose a "*Creasing*"—that is, a double course of slates or tiles laid to breakjoint—is sometimes used. A very good form of coping is one made of a highly vitrified clay, weathered on the upper surface and throated on the underneath to prevent water from running under them. All copings should be set in cement mortar, to minimise the chance of their being displaced. A few examples are shown in Fig. 144—stone copings being left to be dealt with subsequently.

Brick Corbelling.—Brickwork carried out from the face of a wall in projecting courses for the purpose of supporting a load such as that brought by a wall-plate, as shown in Fig. 145, or the end of a beam, is called *Corbelling*. All the projecting bricks should be laid as headers, and should not project more than a quarter of a brick beyond the course below, although, where extra

strength is required, this projection should be reduced to one-eighth of a brick. Where wall-plates have to be carried, the greatest projection should not be less than $4\frac{1}{2}$

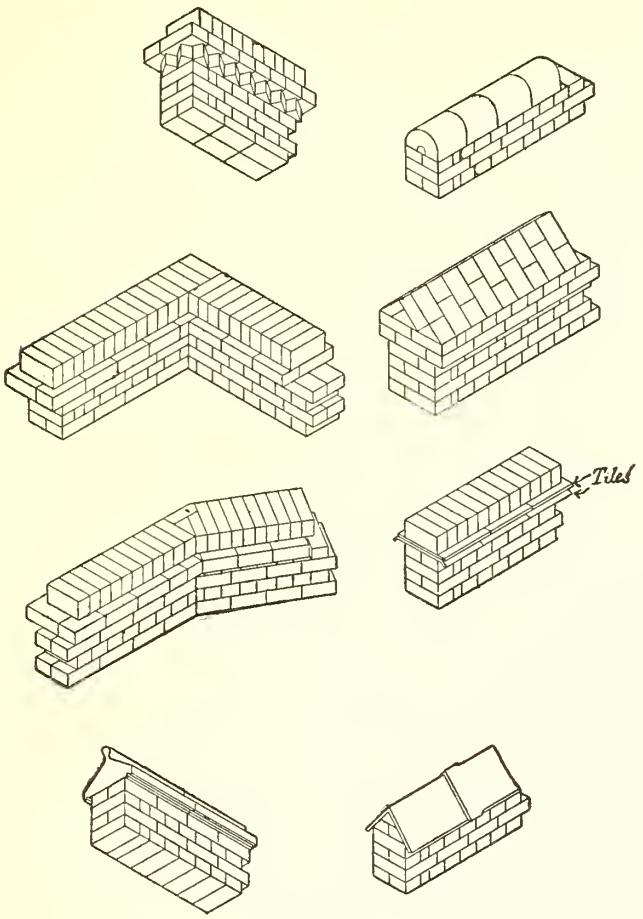


Fig. 144.

inches, and the top course of the corbel should be doubled. It is always best to build corbels in cement mortar.

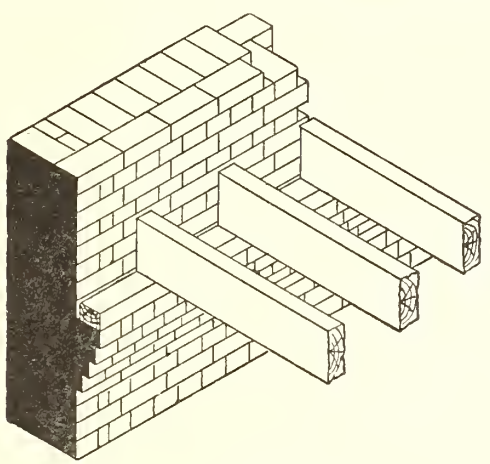


Fig. 145.

Brick Cornices.—Bricks by themselves are not suitable for cornices of very great projection, especially for cornices of the Classic type, though in conjunction with stone they lend themselves very well for this purpose. Cornices should not project more than 9 inches when used without stone to give them strength. Fig. 146 shows a few such cornices

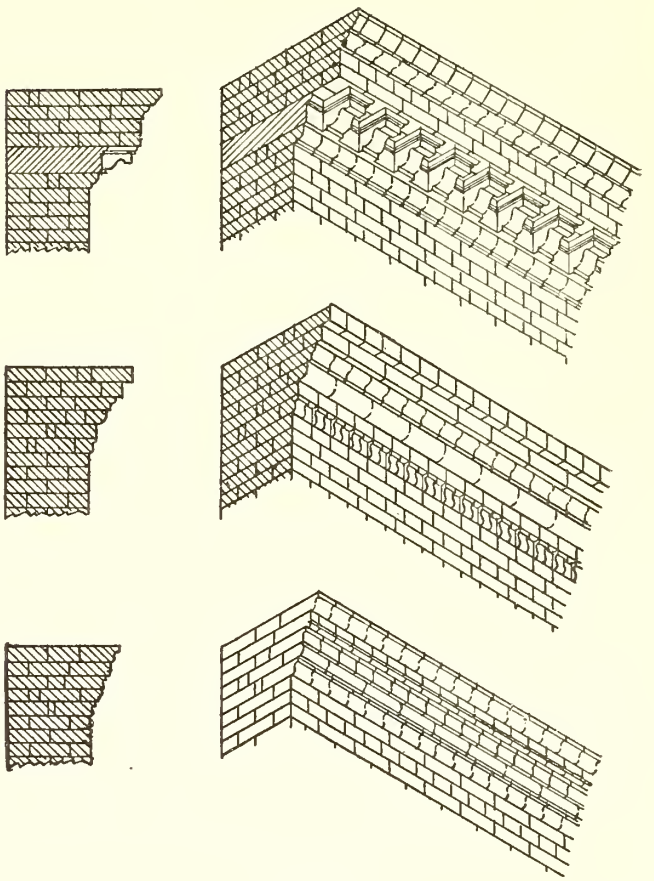


Fig. 146.

On the other hand, bricks lend themselves very well to cornices of the Gothic type, or to what are more correctly termed "Corbel tables," an illustration of

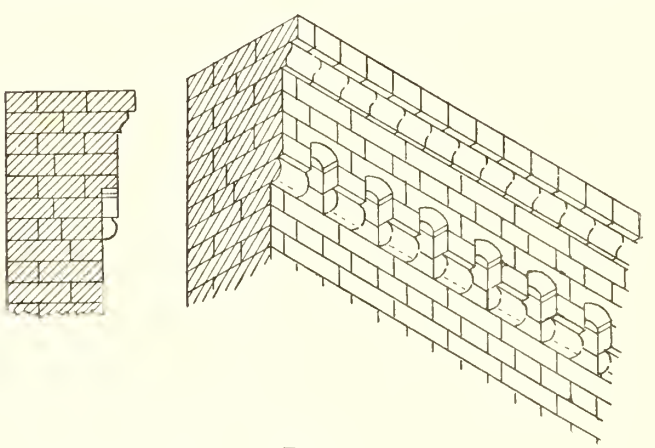


Fig. 147.

which is given in Fig. 147. Cornices, like corbels and all other oversailing courses, of brickwork should be built of headers bedded in cement.

Damp-Proof Courses.—It is of the greatest importance that dampness be excluded from the interiors of buildings, on account of its detrimental effect upon the health of the inhabitants.

Damp can enter a building in any of the following ways: (1) It may pass down through the tops of walls. (2) It may be caused by a driving rain passing through the surfaces of walls. (3) It may be forced through walls and floors of basements in water-logged soils. (4) It may soak up from the footings of walls in damp soil. (5) It may be forced through the lower floors by the movement of ground air. (6) It may pass through the walls and floors of buildings from faulty drains, gutters, or rain-water pipes.

1. Water is prevented from passing down through the tops of walls by fixing copings as already explained, and by the use of lead flashings as described hereafter.

2. Water is prevented from penetrating the surfaces of walls by any of the following methods.

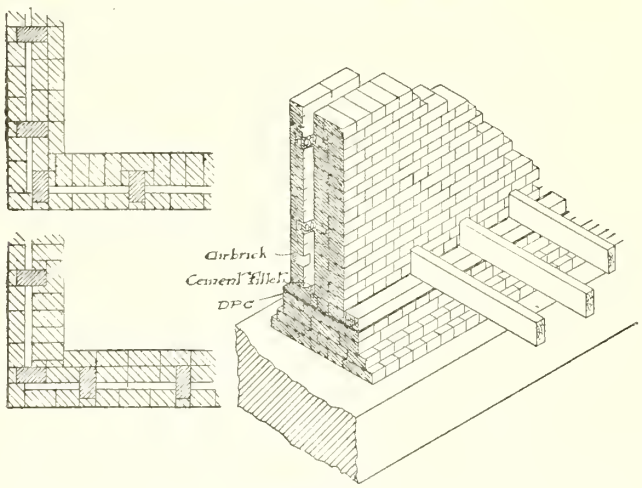


Fig. 148.

Vertical Damp-Proof Courses. — Walls tarred, painted, or treated with any of the water-proofing liquids now on the market offer considerable resistance to the penetration of moisture.

A more lasting method is to rake out the joints and render the whole face of the brickwork in cement mortar, composed of Portland cement and sand in equal proportions. Asphalt may be applied in exactly the same way.

Walls faced with non-absorbent bricks, such as Staffordshire blue bricks, or of stone such as flints split to form fairly flat faces, and set in cement, are very impervious to moisture. Glazed bricks and tiles also form good veneers for the exclusion of damp, and by judicious use of the various colours and designs in which they are now manufactured very fine effects may be produced.

A method of forming damp-proof walls, now much employed in the suburbs of London and in the southern counties generally, is to face walls with tiles hung vertically on battens, as shown in the Chapter on tiling in Volume II. of this work; while in some districts, notably in Hampshire, slates are used in the same manner.

Hollow or Cavity Walls.—In situations exposed to driving rains it is very usual to build walls in two

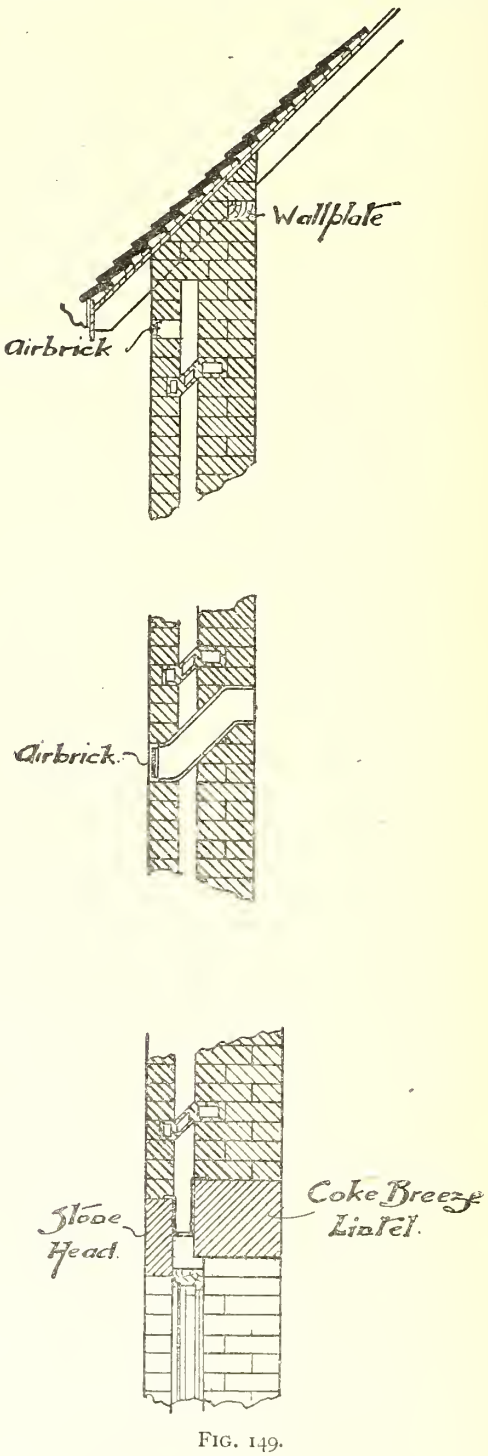


Fig. 149.

thicknesses, to prevent water from soaking through and destroying the internal wall coverings and causing woodwork to decay. In situations near the sea these

cavity walls are particularly necessary, as the salt carried by the wind from the sea is deposited on the exposed surfaces, rendering them permanently liable to attract and hold moisture.

The method of constructing hollow walls is shown in Figs. 148 and 149, in which it will be seen that the thinner skin is placed on the outside, while the thicker or weight-carrying portion is on the inside. The outside skin should not be considered as imparting additional strength to the wall, the inner one being proportioned to carry the weight of the floors and roof by itself.

The outer wall is bonded to the inner by means of specially made ties, either of vitrified stoneware, cast iron, wrought iron or wire, of the shape shown in Fig. 150. These ties are placed in rows from 2 feet 6 inches to 3 feet apart horizontally, and from 9 inches to 1 foot 6 inches vertically, and are set chequerwise. At salient angles or at any point at all subject to rough wear extra bonding ties should be inserted.

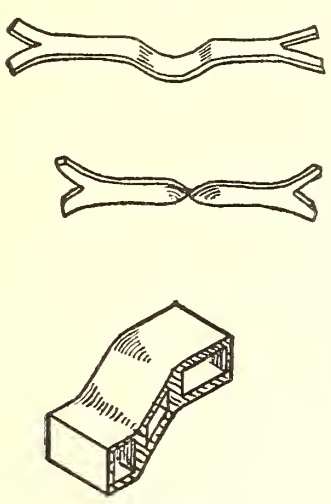


Fig. 150.

In some parts of England it is customary to place the thicker part of the wall on the outside. The objection to this is that the joists and other timbers have to be carried through the inner to the outer wall, giving a ready means for the water to penetrate to the inner surface.

There is another distinct disadvantage in having the thicker wall outside, because its strength is greatly impaired by damp.

The cavity should be provided with ample means of ventilation, and this is done by inserting airbricks at the top and bottom of the walls (see Figs. 148 and 149).

The air for ventilating floors should be taken direct from the outside air and not from the cavity. This is usually done by inserting an airbrick in the outer wall, and carrying a stoneware pipe at the back of it, bent upwards so as to throw any water that may fall upon it to the outer surface, as shown in Fig. 149.

The cavity is sometimes finished off beneath the damp-proof course at the lower end; but the better and more usual arrangement is shown in Fig. 148, where a cement fillet is formed at the bottom to throw any water into small outlets formed at intervals just above the plinth. This prevents the great danger of the cavity forming a pond in the event of a gutter overflowing; but these holes must not be large enough to admit vermin.

Window and door heads should be protected from water by building in a strip of 4 or 5-lb. lead so as to form a gutter, which projects on each side of the opening to enable water to drop clear of the frame. This is shown in Fig. 149. A cement channel coated with asphalt is sometimes used for the same purpose.

The cavity should be closed at the top, as this ensures a more equable temperature in the building.

Great care should be taken to prevent mortar from falling down the cavity in course of building and lodging upon the ties, thus forming a ready means of access for the water. For this purpose iron pipes or battens bound round with hay-bands are laid on top of one row of bonding ties, and are removed when the wall is built up to the level of the next row of bonding ties.

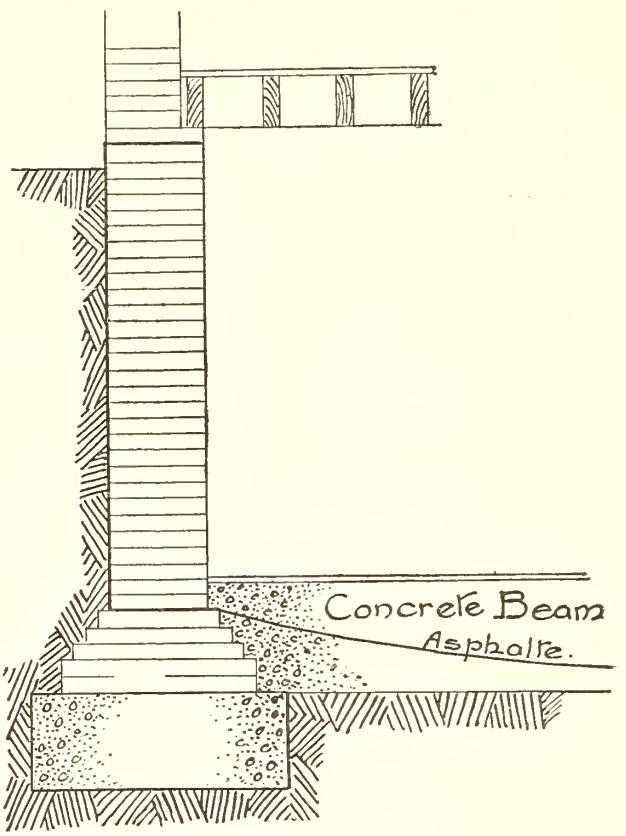


Fig. 151.

It is useful to note that solid and hollow walls of the same thickness cost practically the same amount per rod, the expense of the hay-bands, bonding ties, and the extra labour in the latter making up for the bricks saved by the cavity; but strength for strength the hollow wall is much more expensive, since the strength of the outer skin is of no account, and it is consequently entirely additional to the inner constructional wall.

3. To prevent water from entering basements in water-logged soils it is best to form an asphalt tank, $\frac{3}{4}$ inch thick, completely round the part of the building beneath the ground, carrying it horizontally over the

footing and through the floor. It is best placed on the outside of the walls, so that the pressure of the earth will keep it in position. Above the ground level the asphalt terminates as a horizontal damp-proof course, as shown in Figs. 151 and 152.

Where it is desired to render an existing basement damp proof the existing floor is covered with a layer of asphalt ¾ inch thick, and is weighted down by a layer of concrete 6 inches thick, or a paving of bricks. The joints of the existing wall are then raked out to form a key for the vertical damp course. A board ¾ inch thick is laid flat against the wall with one edge resting on the concrete floor, and three courses of 4½-inch brickwork are built up close against this board, care being taken to have the joints as free from mortar as

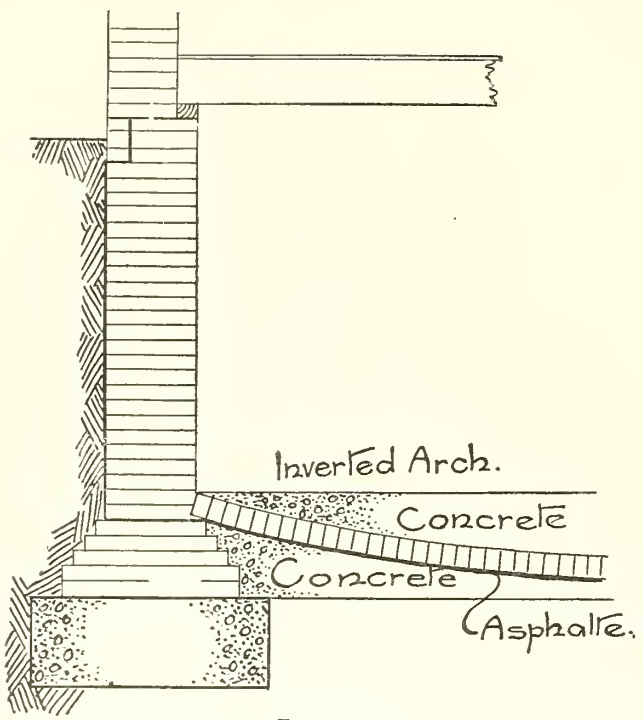


Fig. 152.

possible on the side nearest the board. The board is now withdrawn and the cavity filled up with melted asphalt. The board is now placed with one edge on the uppermost of these three courses, and three more courses are built, the board removed, and asphalt poured into the cavity as before. This operation is carried on until the horizontal damp-proof course is reached above ground level. The section of a basement so treated is shown in Fig. 153.

The above method is not always considered to give sufficient bond between the outer and inner walls when the soil outside is very moist, in which case one header is removed in every square yard of surface on the outer wall to a depth of 4½ inches, and headers are laid tailing into the pockets thus formed, after the latter have been thoroughly lined with asphalt.

Where any of the damp-proof sheetings now on the market are used, headers must be taken out for the insertion of bonding bricks. A bitumen pocket is inserted into the hole in the old wall from which the header has been removed, the edges of which overlap the vertical sheeting (see Fig. 154).

When the pressure of the earth or when the distance between the walls is considerable, it is best to form the concrete floor above the asphalt into a beam curved on the under side, or to form an inverted brick arch, as shown in Figs. 151 and 152.

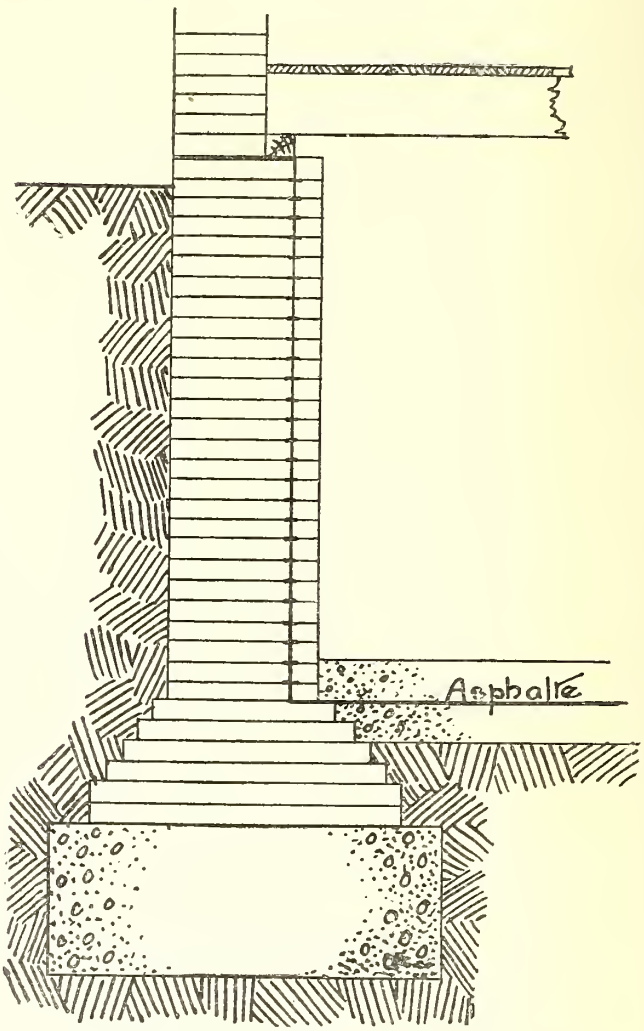


Fig. 153.

Dry Areas.—Moist earth can also be prevented from coming in direct contact with basement walls by means of dry areas. Fig. 155 shows a simple form of dry area much used where rough slabs of stone or slate are available.

Fig. 156 shows another excellent type of dry area, to which the moist earth is prevented from coming in contact with the wall by means of a small retaining wall built at a distance of a few inches from the main wall. Ample means of ventilation should be afforded to these dry areas, open shafts being formed at intervals in the brickwork for the purpose.

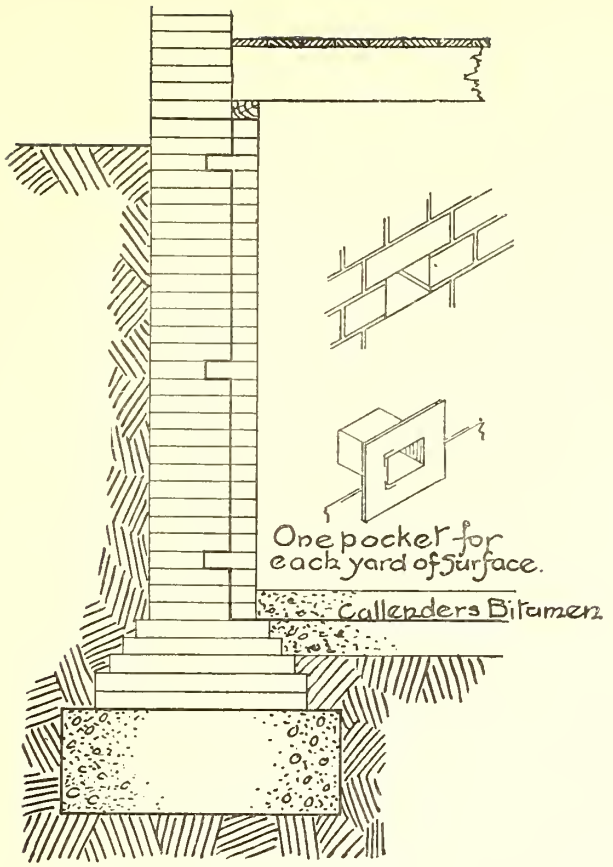


FIG. 154.

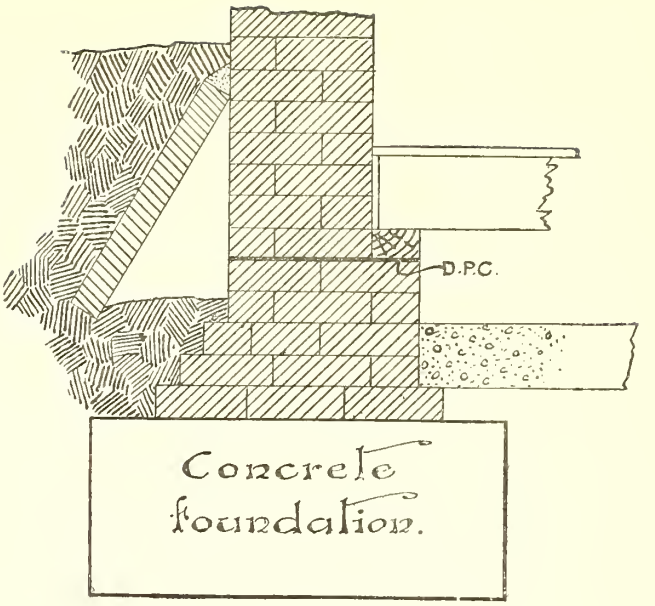


FIG. 155.

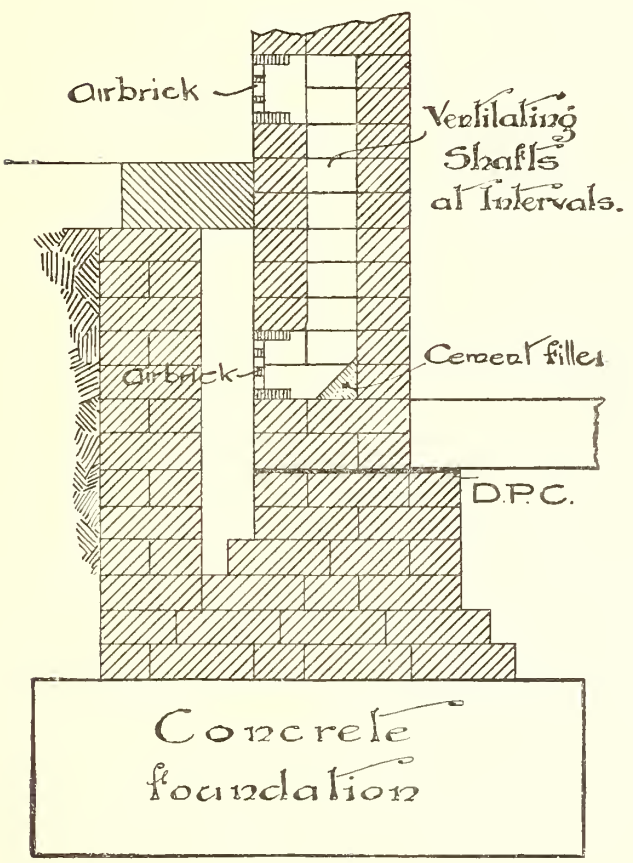


FIG. 156.

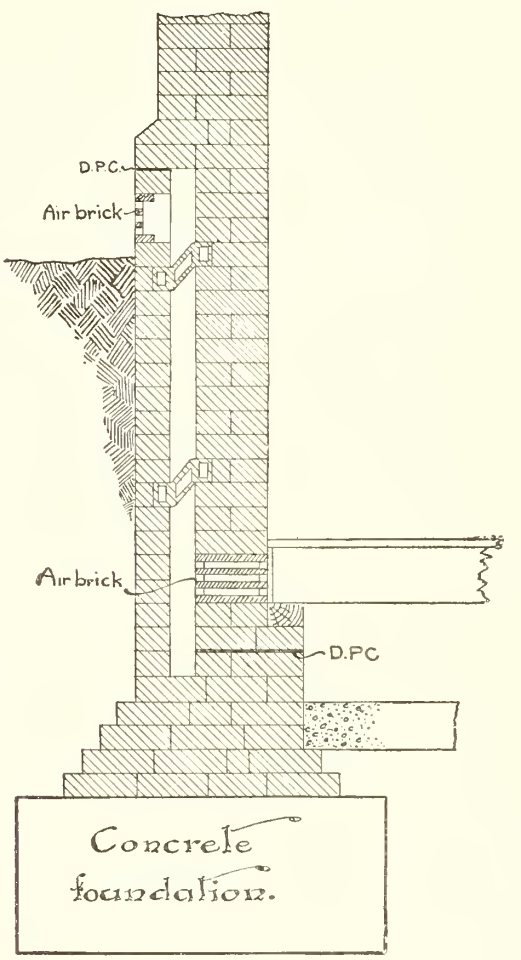


FIG. 157.

Sometimes dry areas are formed in a similar manner to hollow walls, as in Fig. 157. Ample ventilation should be provided to all dry areas and to wood floors below the ground level. The bonding ties for these hollow areas may be formed of bricks soaked in tar or hot pitch, but a more water-proof wall is obtained by the use of proper vitrified stoneware or iron bonding ties.

A very satisfactory dry area is formed by placing a retaining wall at a suitable distance from the basement wall, thus forming an open area, as in Fig. 158. Great

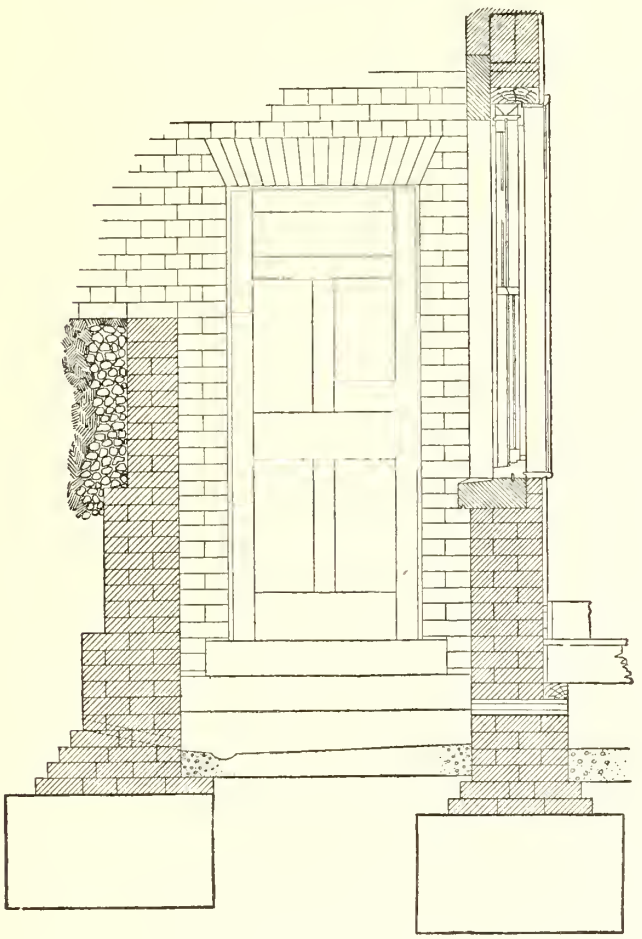


Fig. 158.

economy is sometimes effected by building a flying buttress of brick or iron between the retaining wall and the main wall, as in Fig. 159.

4. Damp must be prevented from soaking up through the foundation of walls by placing a horizontal layer of some impervious material at a distance of from 6 inches to 1 foot above the ground level. These impervious materials are sheet lead, slates, tiles, vitrified stoneware slabs, asphalt, or various combinations of these materials.

Sheet lead forms a very satisfactory damp-proof course, and has the advantage of being very easily applied in strips cut to the width of the wall. There is a tendency, however, for lead to squeeze out a little and to adapt itself to the irregularities of the stones or bricks between which it is laid, causing them to spall at the edges. Some object to the use of lead on the ground that it is decomposed by the action of the carbon-dioxide in the atmosphere, but the action is so very slow as to be inconsiderable. In fact, the carbonate of lead which is formed acts as a protective surface on the lead. Lead is largely used in the upper parts of buildings to prevent the downward penetration of damp, as will be explained when dealing with plumber's work.

When slates or tiles are used they should be in two courses, laid to breakjoint and set in mortar composed

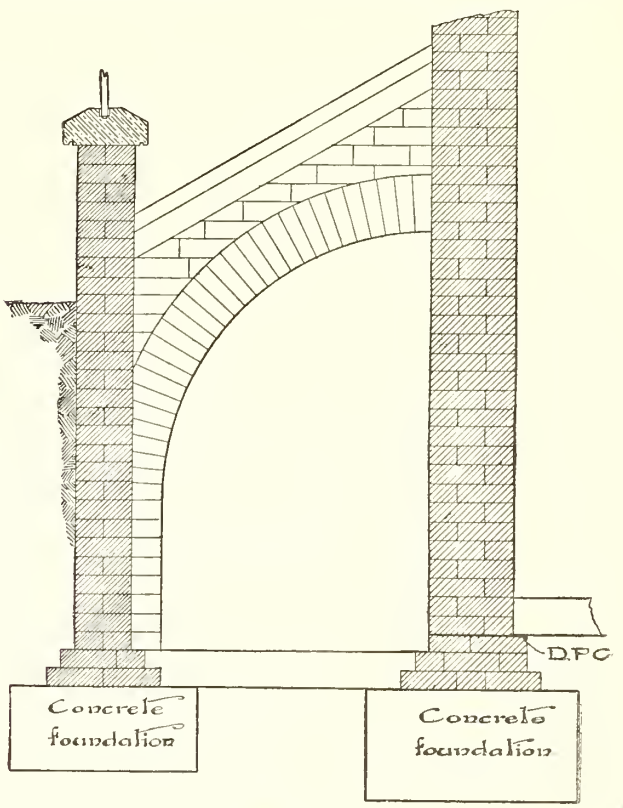


Fig. 159.

of Portland cement and sand in equal proportions. This form of damp-proof course is a very cheap one, and is much used in consequence; but it invariably cracks with the slightest irregularity of settlement in the building, thus permitting damp to rise in places.

Vitrified stoneware slabs form an efficient damp-proof course, and are made in sizes from 1 to $2\frac{3}{4}$ inches thick and 9 inches long, and in widths of $4\frac{1}{2}$, 9, $13\frac{1}{2}$, and 18 inches. They are usually perforated through their widths, and may be used to ventilate the lower floors of a building. They should be laid with their vertical joints open, as shown in Fig. 160, as mortar in this position would assist the upward penetration of moisture. Some of these slabs are made with grooves and tongues on the edges, as the accumulation of dirt

in open joints sometimes allows water to pass upwards through them.

Asphalt in layers of from $\frac{3}{8}$ to $\frac{3}{4}$ inch thick forms, under normal conditions, the most reliable of all damp-proof courses. It is best to use asphalts supplied by firms of established reputation, and when ordering the conditions under which it is to be laid should be fully stated.

The surface to receive melted asphalt should be carefully levelled off as smoothly as possible with mortar to economise materials, and where bricks with frogs in them are used the flat sides should be laid uppermost, and the joints should be thoroughly flushed up with

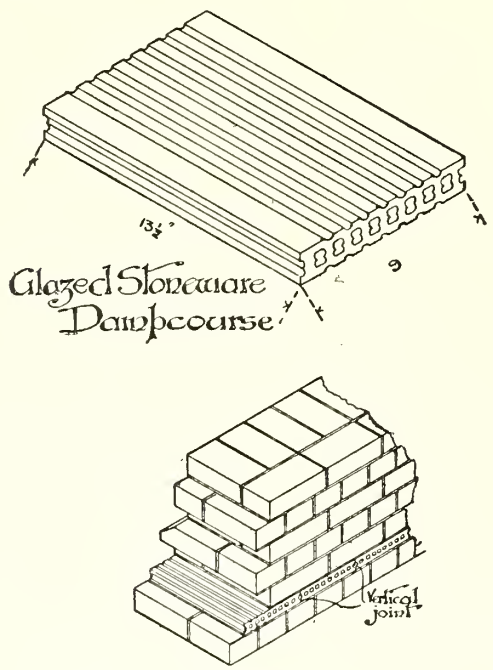


Fig. 160.

mortar. The asphalt in a molten condition is thoroughly mixed with fine grit and laid on the surface thus formed, and spread into an even layer with a wooden float.

A preferable form of damp-proof course now much used is composed of bituminous sheets. It is supplied in strips $4\frac{1}{2}$, 9, $13\frac{1}{2}$, etc. inches wide, and has only to be laid upon the walls at the required level with the joints overlapping. It possesses all the advantages of liquid asphalt, while it is much cheaper and more easily laid.

Similar sheets of felt impregnated with asphalt are also made, but the felt soon decays, leaving insufficient asphalt in the joint to resist moisture.

Hygeian rock in $\frac{1}{2}$-inch layers is also very efficient for horizontal as well as vertical damp-proof courses, and compares very favourably in cost with those made with good asphalt.

Willesden paper is largely used as a damp-proof course for temporary buildings, and is supplied in rolls of the required widths, and is laid with great facility.

5. Ground air, particularly when very moist, is most dangerous to the health, and every precaution should be taken to exclude it from dwelling-houses. Fig. 161

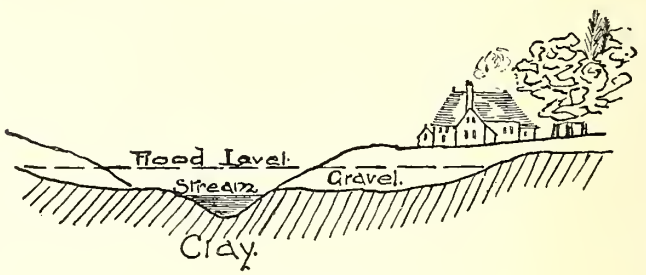


Fig. 161.

shows a house situated apparently in a most delightful position looking down on to a stream. The foundations of the house are formed on good gravel with a subsoil of impervious clay. The river is subject to flood, the level rising as shown. The result of this is that the air contained in the gravel is forced up, and if precautions are not taken to prevent it, it enters the house, carrying with it moist and foul gases. This is prevented by laying a bed of cement concrete over the whole site from 6 inches to 1 foot in depth, and in an extreme case a layer of asphalt should be used, as in Figs. 151 to 154. This example is given as an extreme and obvious case; but ground air is such an unexpected and insidious foe to health that in all good modern building, except it be on rock or chalk, a layer of 6 inches of cement concrete should always be thus laid.

6. Faulty water pipes, drains, and gutters are usually discovered immediately if the fault is great, but if the fault is small it is not so readily detected, especially in the case of drains. The way to prevent this defect is to have all drains, pipes, and gutters, etc. inspected periodically, and all gutters cleaned out once or twice a year, particularly in the autumn, when the leaves have fallen from the trees.

CHAPTER VI

FLUES AND CHIMNEYS

Chimneys are closed channels built of some incombustible material, and are used to cause the draught of air necessary for the proper combustion of fuel in the fireplaces below, and for carrying away the noxious fumes of combustion and discharging them at such a height that they may not be a nuisance to people living in their vicinity.

Chimney Openings.—It is usual, for the sake of economy, to so place the chimney openings on plan that those on the same floor are near one another, and those on different floors over another, so that the flues may be carried up in groups or *stacks*. Some of the different methods of arranging these openings will be seen from the various plans in Part I. of this Volume.

The size of chimney openings is regulated chiefly by the size of the grate it is proposed to use. Kitchens require a width of from 3 ft. to 4 ft. 6 in. and a depth of about 1 ft. to 10½ in., while ordinary grates require a width of 2 ft. 5 in. and a depth of 9 in.; though small bedroom grates are obtainable for openings of even so little as 9 inches. The *Breast* or brickwork above the chimney opening is usually supported on an arch of brick or stone, or upon a bar of wrought iron, and if the breast project more than 4½ inches from the face of the wall, and the jamb on either side be less than 18 inches, the abutments should be tied in by iron bars built into the jambs for at least 9 inches on each side. These bars are called "*Chimney Bars*," and are made from ⅜ to ¾ inch thick and 2 to 3 inches wide, and are shaped as shown in Fig. 162, with

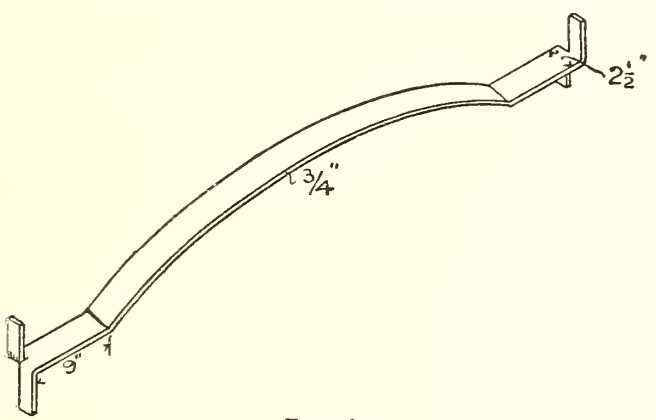


Fig. 162.

the ends split and turned up and down, one bar being used for each 4½-inch horizontal thickness of the arch. Lintels of stone or of coke breeze concrete or fireclay are also used for spanning chimney openings, and cheap substitutes are occasionally employed for these wrought-iron chimney bars.

The Backs of Chimney Openings should not be less than 9 inches, although 4½-chin backs are used for fireplaces both in internal or external walls; but they are unsatisfactory in the latter position, as the warm gases become chilled and the draught is thereby retarded. The backs of chimney openings in party walls from the hearth up to a height of 12 inches above the mantel should be 9 inches thick at least.

The Jambs on each side of every chimney opening should be at least 9 inches wide.

The Flue Linings of every chimney should be at least 4½ inches thick.

Smoke Flues.—The brickwork above the fireplace is gathered over or contracted above the openings in order to reduce its size to that required for the flue. This is done by projecting the courses as in corbels, the oversailing angles being cut off in good work, as they tend to check the up draught. The gathering over should also be performed in as short a height as possible consistent with good bond in the brickwork, as a large space above the fire is productive of sluggish draught until the fire beneath has thoroughly burnt up.

Brick flues for kitcheners are usually made 14 by 9 inches, while those for ordinary fireplaces are more often 9 by 9 inches. All are rectangular in shape. Circular fireclay tubes 10 inches in diameter (see Fig. 163) are also used for flues, and they possess the advantages that—

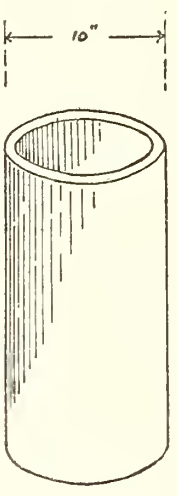


Fig. 163.

They retain the heat, thus making the draught more regular;

They offer less resistance to the passage of the waste products of combustion;

They lessen the risk of fire or of smoke penetrating into adjoining flues;

They are not easily dislodged, as bricks are apt to be by clumsy sweeping;

They are easily fixed in position.

They are, however, too smooth for soot to properly collect on, so that it soon falls on the fire and becomes a nuisance, while the brickwork has to be cut to fit round the pipes and the space between to be thoroughly grouted, which tends to imperfect work.

All flues are inclined, as shown in Fig. 164, with easy curves at the junctions of straight portions, to reduce the risk of down draughts and to bring them away from the fireplaces above. The amount of projection of the bricks in successive courses necessary to produce the required angle of inclination is usually determined as shown in Fig. 164. The distance X is 4 feet 6 inches (*i.e.* 18 courses), while Y is 4 feet 6 inches; then the projection of each brick will be 54 inches divided by 18, which is equal to 3 inches. Blunders, which can only be remedied by pulling down the brickwork for the distance X, often occur through workmen neglecting to make this simple calculation. The projecting angles of the bricks should be cut away and the receding angles on the opposite side of the flues filled up with mortar.

The *Withes* or partitions between the flues should never be less than $4\frac{1}{2}$ inches. These may be inclined at any angle if soot doors are built into them, but in no other case should they be inclined at a smaller angle than 45 degrees to the horizon. When a flue is inclined at an angle of less than 45 degrees its upper side should be composed of 9-inch brickwork. It is

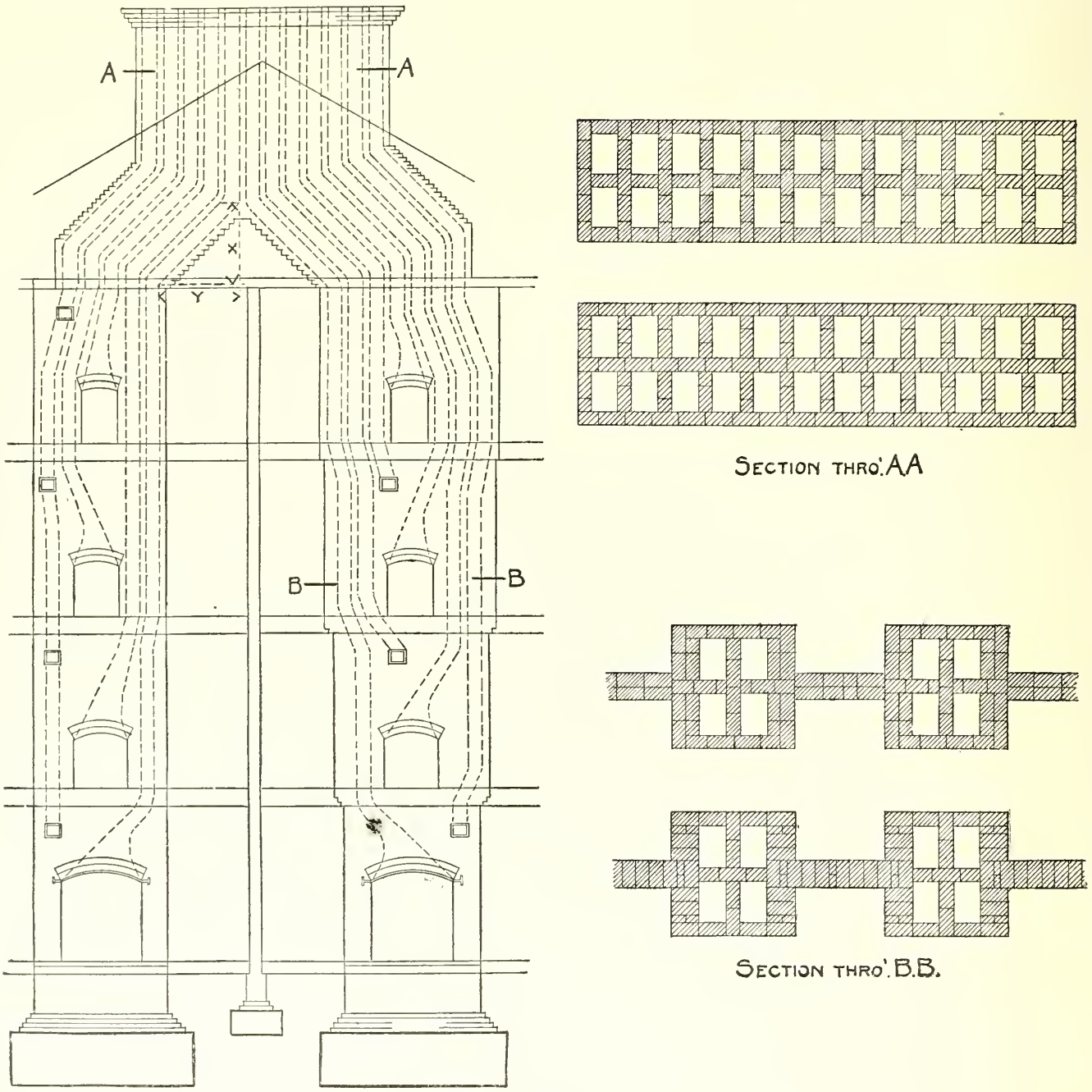


FIG. 164.

always better to make the inclination of flues at such angles that the offsets in the brickwork need not exceed one-sixth the length of a brick.

Soot Doors are doors of iron which are let into the breasts of inclined flues to enable them to be swept properly. They are made in various sizes, but those less than 40 square inches in area should not be used.

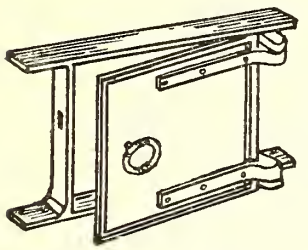


Fig. 165.—Soot Door

Woodwork should not be fixed within 15 inches of a soot door. Fig. 165 shows the type of soot door in common use.

Ventilation Flues.—Openings are sometimes left in the smoke flues for the insertion of ventilating valves (see Fig. 166), which should not be fixed nearer than 12 inches to any timber or other combustible material, they being placed as a rule at 12 inches or so below the ceiling line. Sometimes special flues are constructed for ventilating purposes, as on the left-hand side of Fig. 164, a single flue serving for all the rooms adjoining the chimney stack; while on the right-hand side of the same Figure the far more satisfactory arrangement of separate flues for each room is employed. These flues are constructed in precisely the same manner as are smoke flues, and terminate with chimney pot, cowls, or cast-iron airbricks built into the stack.

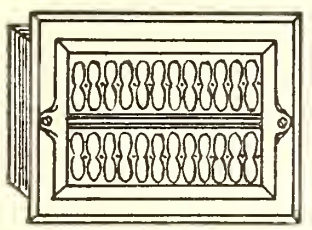


Fig. 166.—Valve for Ventilating Flue.

Pargeting Flues.—The insides of all flues, unless lined with fireclay, should be pargeted, *i.e.* rendered with mortar ½ inch thick. The object of this is to prevent the accumulation of soot in the joints of the brickwork, and so lessen the risk of fire penetrating to the woodwork near the flues.

At one time the mortar used for *parget* was composed of one part of lime to three parts of dry cow-dung. This forms a very tough and fire-resisting composition, and is still used in districts where the cow-dung is to be easily obtained, but in towns ordinary lime and sand mortar has taken its place.

The outside of every flue should also be rendered where it passes through a roof or floor.

Coring Flues.—In building chimneys it is almost impossible to prevent mortar and pieces of brick falling down them and lodging on the lower sides of bends, and if these obstructions are not removed they considerably check the draught and cause great accumulations of soot. To prevent this defect a *sweep*, or bundle of rags or hay, is drawn up the flue as the work proceeds and a wire brush is passed through after the work is complete. Sometimes holes 12 by 9 inches are left in the breasts where the bends occur, so that they may be cleared of loose matter.

Stacks.—Above the highest chimney opening the flues are brought together and carried out through the roof as one stack. The outside walls of chimneys above the roof are usually made 4½ inches thick, but the draught is apt to be retarded by the hot fumes becoming chilled, for which reason it is better to make them 9 inches thick. The best position for a chimney stack is at the ridge of a roof, while the worst is at the eaves. Of course, it cannot be said that a chimney in the latter position is sure to smoke, but there is certainly a greater tendency for it to do so than one surmounting a ridge.

Fires belonging to stacks near tall buildings, cliffs, and tall trees almost invariably smoke, even when the flues are terminated in a cowl or windguard, owing to the air currents becoming diverted in a downward direction.

Height of Chimney Stacks.—Every chimney stack or smoke flue should be carried up to a height of not less than 3 feet above the roof, flat or gutter adjoining thereto, measured at the highest point in the line of junction with such roof, flat, or gutter. It is better, however, to carry up all chimneys, where they occur in the lower parts of roofs, well above the highest parts of such roofs, bearing in mind at the same time that a chimney should not be built higher above the roof than six times the least width of the chimney at the level of the highest point in the line of junction with the roof, unless such chimney is built with and bonded to another chimney. Tall chimney stacks may be rendered secure by means of iron braces or flying arches between two stacks.

At least the highest six courses of a chimney stack should be built in cement.

Hearths.—There should be laid level with the floor of every storey, in front of the opening of every chimney, a slab of stone, slate, or other incombustible substance at least 6 inches longer on each side than the width of the opening, and at least 18 inches wide in front of the breast. Such slabs should be laid wholly upon brick, stone, or iron bearers, or upon brick trimmers or other incombustible material, and the slab and incombustible material upon which it is bedded should be solid for a thickness of at least 6 inches beneath the upper surface of such slab.

Where the space between the lowest floor and the concrete over the site is small the hearths are bedded on to the latter, or the height is made up where necessary with brickwork or fine concrete. This applies to all concrete floors at any level throughout a building. Where this space is great the hearths are supported by dwarf or fender walls, as shown in Figs. 167 and 168, according to their height and the weight brought upon them, usually from 4½ to 9 inches thick, resting upon proper footings, which in turn are carried either by the 6-inch concrete over site or by the

foundation-bed of the chimney projected out for this purpose. The space within the fender wall is partly

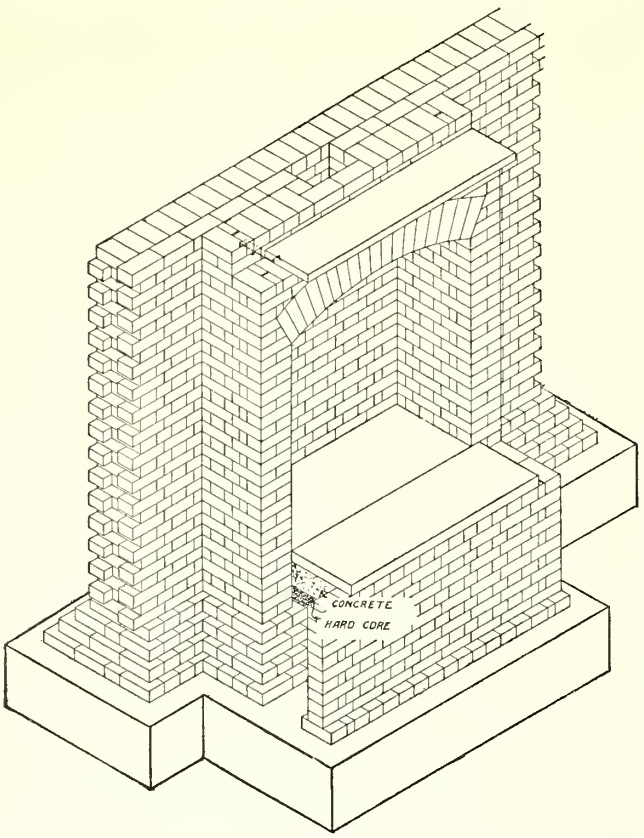


Fig. 167.

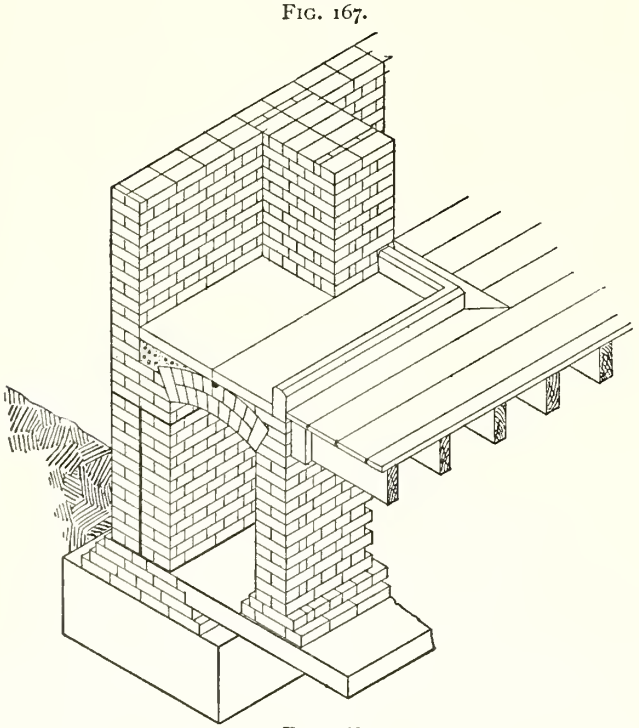


Fig. 168.

filled with hard cone, on top of which a concrete bed is formed from 4 to 6 inches thick, according to the size of the hearth which is bedded upon it, as shown in Fig. 167. Sometimes rough *Trimmer Arches*, as in Fig. 168, are used to span the space between the main and fender walls, the latter being buttressed by means of cross sleeper walls or tied by means of iron rods to the main wall.

The construction of hearths in upper wooden floors is shown in Fig. 267, Chapter XVIII.

Hearths may be of stone, brick, tile, or any other incombustible material. When of stone they are usually made 2 inches thick, and $\frac{1}{2}$ inch is allowed for bedding them in cement. Tiles are also used for hearths, and vary in thickness from $\frac{1}{2}$ to $\frac{3}{4}$ in. Marble hearths are made from $\frac{3}{4}$ to 1 inch in thickness, and

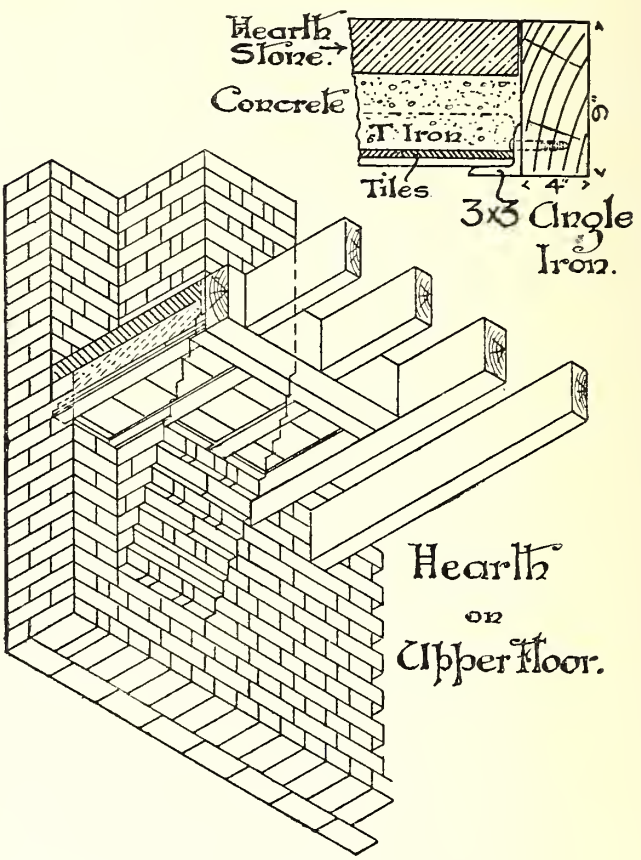


Fig. 169.

great care must be taken to prevent lime mortar coming in contact with them, or in fact with any marble work, as it causes dirty brown stains; for which reason all the built-in parts of marble work are coated with a slip of plaster of Paris.

Foundations of Chimneys.—The London Building Act says that chimneys shall be built upon solid foundations, and with footings similar to the footings of the wall against which they are built, unless they are carried upon iron girders with direct bearings upon party, external, or cross walls.

It will be seen, by referring to the plans contained in Part I. of this Volume, that the loads borne by

the foundations of chimneys are much greater in proportion than the loads borne by the foundations of walls against which the chimneys are built. It is therefore necessary to proportion their foundations to meet this greater load, in accordance with the principles set forth in Chapter I. When a stack is very high it is best to form an inverted arch between the lowest jambs.

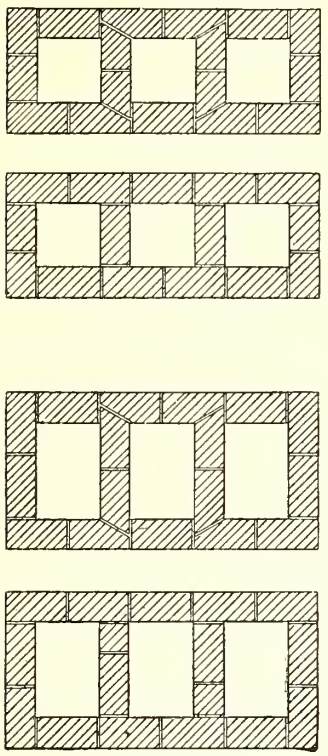


Fig. 170.

Chimneys do not always start from the lowest floor, in which case the breasts should be supported on corbels of brick, stone, or other incombustible material, and the work so corbelled out should not project from the wall more than the thickness of the wall measured immediately below the corbel. Fig. 169 shows a corbel suitable for carrying the chimney breasts on an upper floor, and also a method of supporting the hearth upon a system of T and L irons, tiles being supported upon the tables of the T irons as a permanent centering for the concrete bed under the hearth.

Bond in Chimneys.—In bonding chimneys where the external walls are 4½ inches thick it is almost a universal practice to use stretcher or chimney bond, as shown in Figs. 170. It is most essential to the strength of a stack to make the withes bond well into the external walls, but in stretcher bond this cannot be done in a very satisfactory manner without expensive cutting. The usual way of bonding the withes is by splaying the bricks of one course as shown in Fig. 170. To avoid this defect English and Flemish bond are used, although their use necessitates a great amount of cutting when the external walls are only 4½ inches thick (see Fig. 171). The difficulty is, however, overcome by alternate courses of Flemish and stretcher bond, as in Fig. 172. When the external walls of chimneys are 9 inches thick they are usually built as far as possible in English bond or Flemish bond, as in Fig. 172.

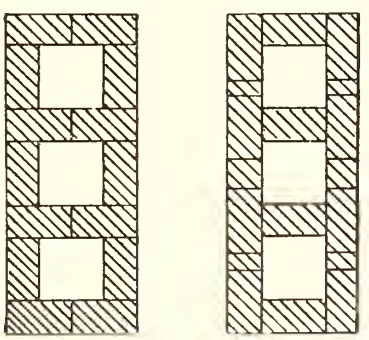


Fig. 171.

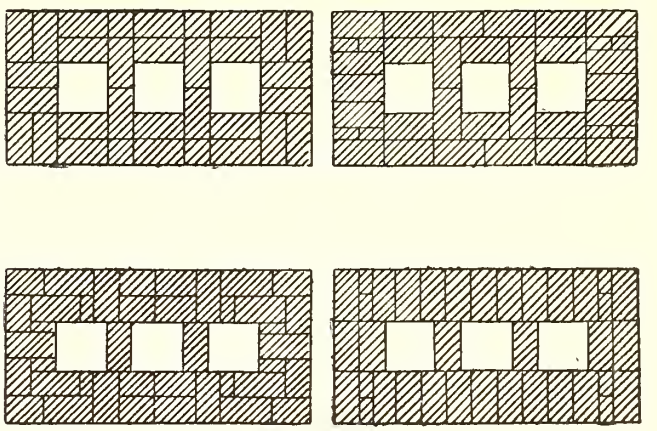


Fig. 172.

When the flues are of different sizes it is often difficult to build stacks in any particular bond, it being better in such cases to devise a method of bonding for each particular case, and to pay very little attention to the arrangement of the bricks or the faces, as shown in Fig. 173.

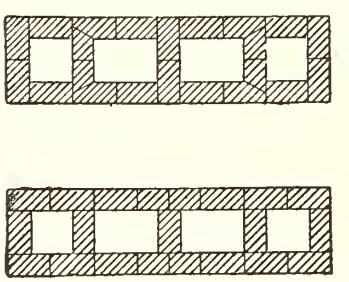


Fig. 173.

Chimney stacks may be made very ornamental in character by the judicious use of cut or specially made bricks.

CHAPTER VII

GAUGED WORK—ARCHES—BRICK-CUTTING

When a neater appearance than that of ordinary brickwork is required, soft bricks of even texture, called *Cutters* or *Rubbers*, are used, which are cut and rubbed till their surfaces are so regular that a joint $\frac{1}{32}$ inch thick may be obtained. Brickwork built of bricks cut and rubbed in this manner is called *Gauged Work*.

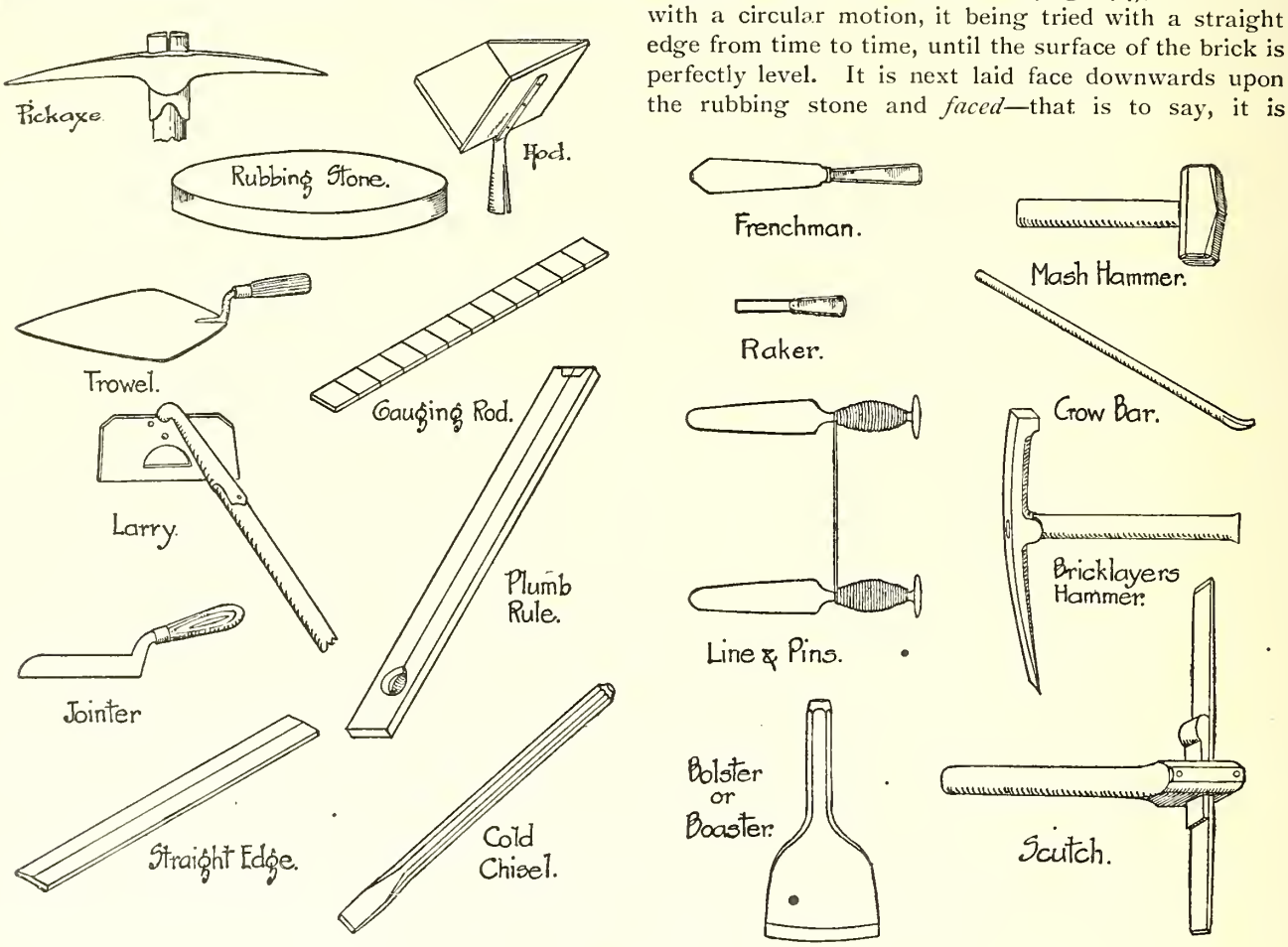


Fig. 174.

Gauged Work.—The simplest form of gauged work is that known as *Plain Ashlar*—that is to say, plain walls built, or rather faced, with cut and rubbed bricks; for the cut bricks are only used as a facing to a wall, rough brick being used for the interior. Before commencing to cut the facing bricks, therefore, the size of the backing bricks should be measured. Let it be assumed for the sake of explanation that the backing bricks, together with one mortar joint, averages 9 inches in length, $4\frac{1}{2}$ inches in width, and 3 inches in thickness.

Cutting and Rubbing the Bricks.—Each brick is first *bedded*—that is, it is laid with the frog or wide side downwards upon a *Rubbing stone* (Fig. 174), and rubbed with a circular motion, it being tried with a straight edge from time to time, until the surface of the brick is perfectly level. It is next laid face downwards upon the rubbing stone and *faced*—that is to say, it is rubbed until the face is even and square with the bed, a *square* being placed with its stock against the bed and the blade against the face, as shown at A, Fig. 175. One end of the brick is then rubbed smooth and squared with the bed and face. The thickness of the brick is now reduced to $3-\frac{1}{32}$ inches in a *Reducing box*, shown at B, by filing away the upper surface to the dimension of the box. Every brick is treated in this manner, but if a brick is to be a stretcher the length is now reduced to $9-\frac{1}{32}$ inches—that is to say, to the average length of the backing bricks less the

thickness of one joint in the gauged work. This operation is performed by laying the bricks two at a time bed downwards in a box the internal length of which is $9-\frac{1}{32}$ inches, with the squared ends flat against the ends of the box, as shown at C, Fig. 175. The projecting ends of the bricks are then cut off with a *Bow saw* run down the open ends of the box, and if necessary the cut end is trimmed with a file. The box, which is technically termed a *Lengthening box*, although its use is actually for shortening the bricks, has the edges upon which the saw runs bound with sheet iron for protection. The blade of the saw is composed of two lengths of No. 16 B.W.G. mild steel wire twisted as shown to a larger scale on B, Fig. 185.

If the brick is to be used as a header it is treated similarly to a stretcher, save that the length need not

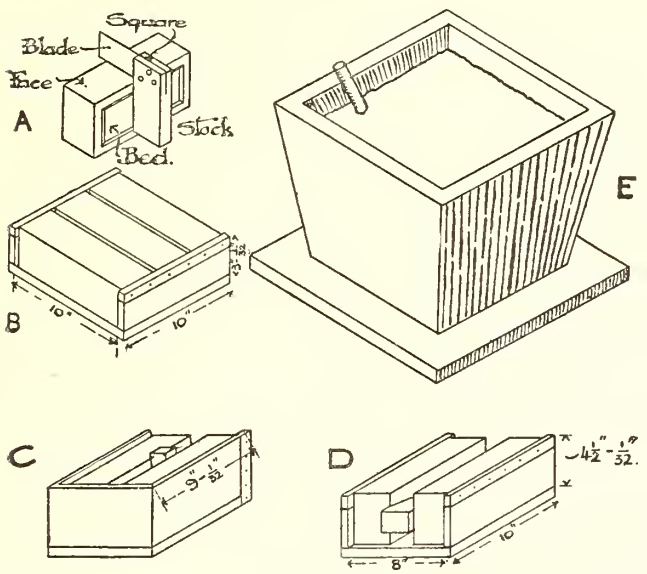


Fig. 175.

be reduced, the backing bricks being cut with a trowel to fit the facings; but the width must be reduced to $4\frac{1}{2}-\frac{1}{32}$ inches in a box whose internal height is of this dimension, as shown at D, Fig. 175.

Setting Gauged Work.—Bricks in gauged work are usually set in lime putty mixed to the consistency of cream, and strained through a sieve with about 400 meshes to a square inch into a *Putty tub*, E (Fig. 175). This tub usually has a capacity of about one cubic foot. Each brick is taken up, and the faces to be bedded or jointed are just touched upon the surface of the putty, when an amount sufficient to form the mortar joint will adhere to them. The putty should be constantly stirred to prevent the lime from settling. The bricks are then placed carefully into position upon the wall, the backing being built up simultaneously with the gauged work. Cement or other quick-setting mortar is used for the backing to minimise the settlement of the joints.

Arches.—An arch is an arrangement of bricks, blocks of stone or other material for spanning an opening, and constructed in such a manner that the blocks mutually support one another, and divert the vertical pressure brought upon them by the load in an inclined direction to the supports at either side of the opening.

If carefully jointed with cement, and built of a hard material, arches over small openings practically act as lintels, and exert a vertical pressure upon their supports. Should a crack appear in an arch, however, after it has been built it will exert an outward thrust upon its supports. Arches over large openings always exert an outwardly inclined pressure upon their supports. For these reasons the supports should be made large enough to resist the maximum outward thrust that is ever likely to be brought upon them.

The following are the technical terms relating to arches:—

Face.—The exposed surfaces of an arch ring are called its faces.

Voussoir.—The blocks forming an arch ring are called voussoirs.

Key.—The central or uppermost voussoir is called the key or keystone.

Springers.—The lowest voussoirs of an arch ring are called the springers.

Skewbacks.—The bricks or stones cut to the necessary slope to receive the springers are called skewbacks.

Intrados or *Soffit.*—The inner curve of an arch ring is called the intrados or soffit. The term soffit is also applied to the whole of the under surface of an arch.

Extrados or *Back.*—The outer curve of an arch ring is called the extrados or back. The term back is also applied to the whole of the upper surface of an arch.

Springing Points.—The extremities of the intrados and extrados are called springing points.

Springing Line.—The horizontal line drawn through the springing points of the intrados is called the springing line. This term is also applied to the line formed by the junction of the under surface of the arch with its support.

Span.—The horizontal distance between the springing points of the intrados is called the span.

Rise.—The vertical distance from the springing line to the highest point of the soffit is called the rise.

Crown.—The highest point on the extrados is called the crown.

Haunches.—The lower portion of an arch from the springing to a point midway between the springing and the crown are called the haunches.

Spandrel.—The triangular spaces above the haunches of an arch are called the spandrels.

Arcade.—A series of arches with its supports is called an arcade.

Abutment.—An isolated mass of masonry supporting one end of an arch is called an abutment, or more correctly an abutment pier. The term abutment is usually applied to the end support of an arcade.

Pier.—The intermediate supports of arcades are called piers.

Columns.—A pier whose horizontal section is a circle or a regular polygon is called a column.

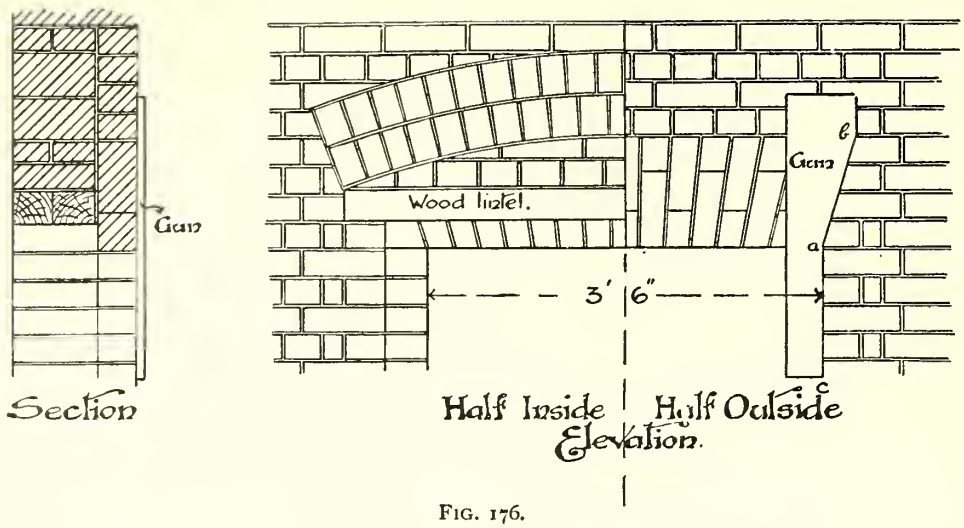


FIG. 176.

Shaft.—The portion of a column between the base and the capital is called the shaft.

Respond.—A half-column, pilaster, or corbel attached to a wall to carry one end of an arch is called a respond.

CLASSIFICATION OF ARCHES.—Arches may be classified, according to the shape of their intrados, into three groups—(1) flat arches; (2) arches struck from centres; (3) arches whose intrados forms a curve other than a segment of a circle.

1. An example of a flat arch is shown on the left-hand side (exterior) of Fig. 176.

2. Arches struck from centres may themselves be classified according to the number of centres used in striking them, as shown in Fig. 177.

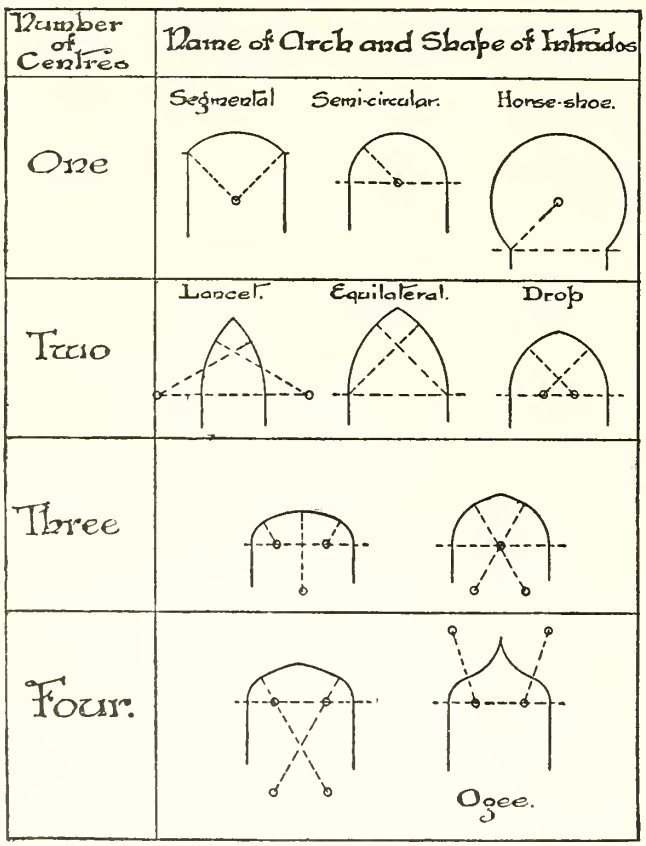


FIG. 177.

NOTE.—Arches struck from two, three, and four centres are met with in Gothic work.

Semicircular arches are met with in Classic, Romanesque, and Renaissance work.

Segmental arches are used considerably in Renaissance work, and are not infrequently used in Gothic work.

The horseshoe arch is of Sarasenic origin.

The three-centred arches are often considered as particular cases of the four-centred arch.

3. Arches in this group are usually elliptical, parabolical, hyperbolical, etc.; but the elliptical arch is practically the only one used in architectural work.

Arches may again be classified into three groups according to their workmanship, as follows:—

(*a*) Rough arches.
(*b*) Axed arches.
(*c*) Gauged arches.

ROUGH ARCHES are used when the appearance of an arch need not be considered, or when it is intended to

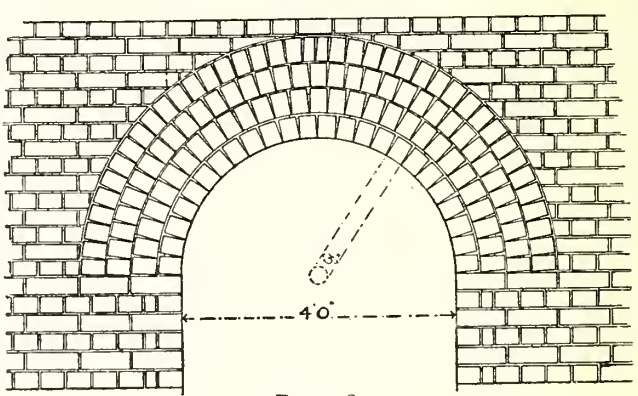


FIG. 178.

plaster over the face of the arch, as in internal doorways. The bricks are not cut to a wedge shape, but

Capital.—The ornamental head of a column is called a capital.

Base.—The moulded foot of a column is called the base.

the necessary radiation is obtained by setting them with the edges close together on the soffit and open on the extrados, so that the mortar joint becomes wedge shaped, and radial lines would pass through the centre both of the joints and the bricks. Fig. 178 shows a rough semicircular arch, suitable for an internal door opening, composed of four concentric or *rowlock* rings, $4\frac{1}{2}$ inches deep.

It will be noted in Fig. 178 that there is no tie between the concentric rings save that of the adhesion of the mortar. This defect is remedied by laying courses of headers, called *Lacing Courses*, to bind the rings together at intervals where the joints in the rings most nearly coincide, as in Fig. 179. In arches of

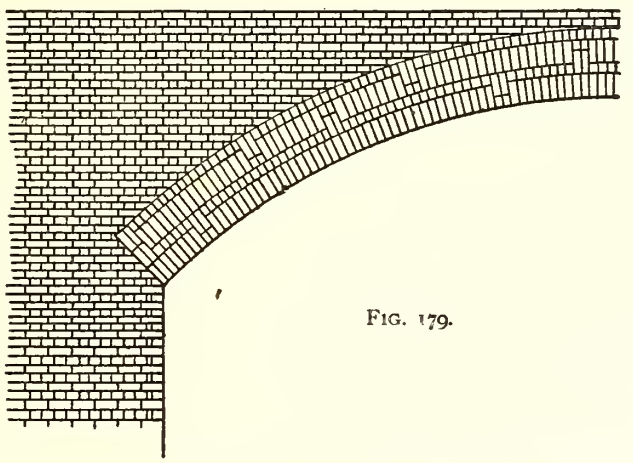


Fig. 179.

quick curvature it is better to roughly cut the bricks of the lacing courses to the proper wedge shape in order to avoid very large joints on the extrados. In large arches the bricks of the lacing courses need not be cut and need not pass right through the entire thickness of the arch, but pairs of rings may be laced together, as in Fig. 179.

Relieving Arches.—Rough arches of small rise are used in conjunction with lintels to relieve the latter of

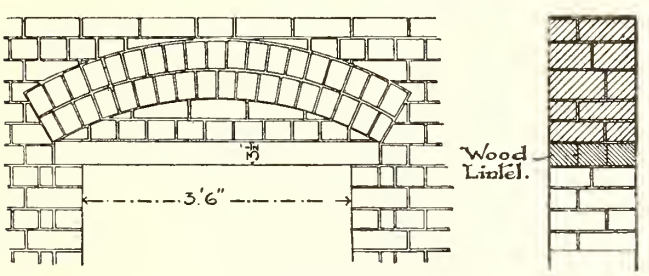


Fig. 180.

the superincumbent weight ; these are termed *Relieving* or *Discharging* arches. The most frequent position for such arches to occupy is over door. and window openings. The usual method of construction for door openings is shown in Fig. 180. The opening is first bridged by a wood lintel, which should project at least $4\frac{1}{2}$ inches on either side of the opening. The depth of the lintel in inches should be at least equal to the span of the opening in feet, but no lintel should be used less than 3 inches deep. Lintels are usually cut out of $4\frac{1}{2}$-inch battens, as this size is most convenient for brick walls, whose thicknesses are multiples of $4\frac{1}{2}$ inches. A brick core is now built on top of the lintel. To do this a $\frac{1}{2}$-inch board is cut to the required curve ; bricks are

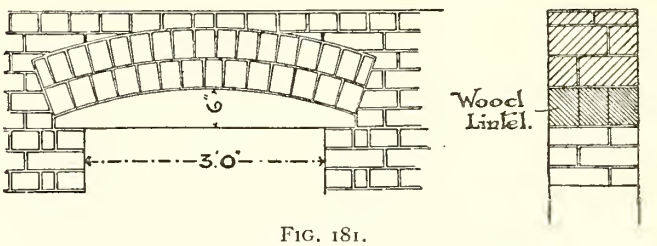


Fig. 181.

then laid on top of the lintel, the mould laid against them, and the curve marked upon their faces. The bricks are then cut with an axe and set. The skew-backs are then formed and the arch built up, using the core as a turning piece. The span of a relieving arch should be at least as long as the lintel.

Sometimes when the opening in a wall is small the lintel is cut on the upper side to the shape of the soffit of the arch, as in Fig. 181.

The lintel is not intended to impart strength to the relieving arch, for should the lintel shrink or become destroyed by fire the weight over the opening must

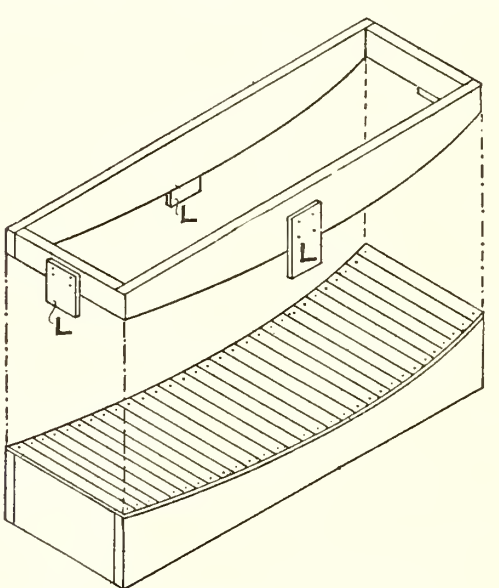


Fig. 182.

rely entirely upon the arch for support. The use of the lintel is for fixing the joinery work.

Lintels cast of coke breeze concrete in wooden moulds are often used in place of wood lintels, and they possess the advantage of being fire-resisting. They are easily formed, and they do not shrink and become loose. A wooden mould for a concrete lintel is shown in Fig. 182. The upper portion fits upon the

lower, and is kept in position by projecting lugs L. The trough thus formed is well oiled or smeared with soft soap on the inside to prevent the concrete from adhering to the sides, it is then filled with concrete and the top floated level by running a straight piece of wood along its upper edges.

Inverted Arches.—Rough or uncut bricks are used for forming inverted arches, the function of which has been already explained in Chapter I.

Axed Arches are those built of bricks which have been cut with an axe, or with a bolster and club hammer (see Fig. 174), to the approximate wedge shape. The arch is set out and a template obtained as for gauged arches.

When glazed bricks are used for axed arches they are cut off to a template obtained as explained for gauged arches, but placed over the bricks so as not to cut away the glaze on the soffit.

The name "axed arch" is sometimes applied to arches whose voussoirs have been cut as in gauged work, but with less care and exactness.

Gauged Arches are arches formed of bricks which have been carefully cut and rubbed upon a stone so that the arrises are sharp, the exposed faces smooth and even, and the joints fine.

The Semicircular Gauged Arch.—Let us suppose that we wish to build an arch 12 inches on face and $4\frac{1}{2}$ inches on soffit over a span of 4 feet 6 inches (Fig. 183).

Setting out.—A little more than half the outline of the arch must first be set out to full size on white lining paper pinned to a large board (usually from 5 to 6 feet square), the arco being struck with a radius rod—that is, a rod of wood pivoted at one end and with a pencil point fixed to the other. Now, taking a distance of $1\frac{1}{2}$ inch in the dividers, prick round the extrados, starting from the point B (Fig. 183), and continuing until the point C is reached. If the point of the dividers does not fall exactly upon C, then the distance taken with the dividers must be slightly increased or decreased until the extrados exactly contains an *odd* number of these small distances. In Fig. 183, D is the first of these pricked points after the distance has been adjusted as described above, and E is a point pricked at the same distance on the other side of the central point B, so that ED is approximately 3 inches. Join D and E to the centre A, thus indicating the joints of the key brick, and produce AD to F.

Preparing Template.—Now take a piece of board 18 by $3\frac{1}{4}$ by $\frac{1}{2}$ inches (T, Fig. 183), planed on both faces and with one edge shot square and true, and place it with the shot edge coinciding with the line AE. Take a long straight edge and place it over T with one edge exactly over the line AF, and draw a line on T along the edge of the straight edge. Next cut T to this line, and shoot the edges true and square. Then T will be the template as shown in Fig. 183. The template must now be tested for accuracy, which is done by an operation called *Traversing*, performed in the following manner: Place the template over the drawing of the key brick as in the lower drawing of Fig. 183, adjusting it to fit exactly, and make a pencil mark on the left-hand edge immediately over the intrados line. This point is called the *Filling-in* mark. Place the straight edge V against the edge of T, remove T and

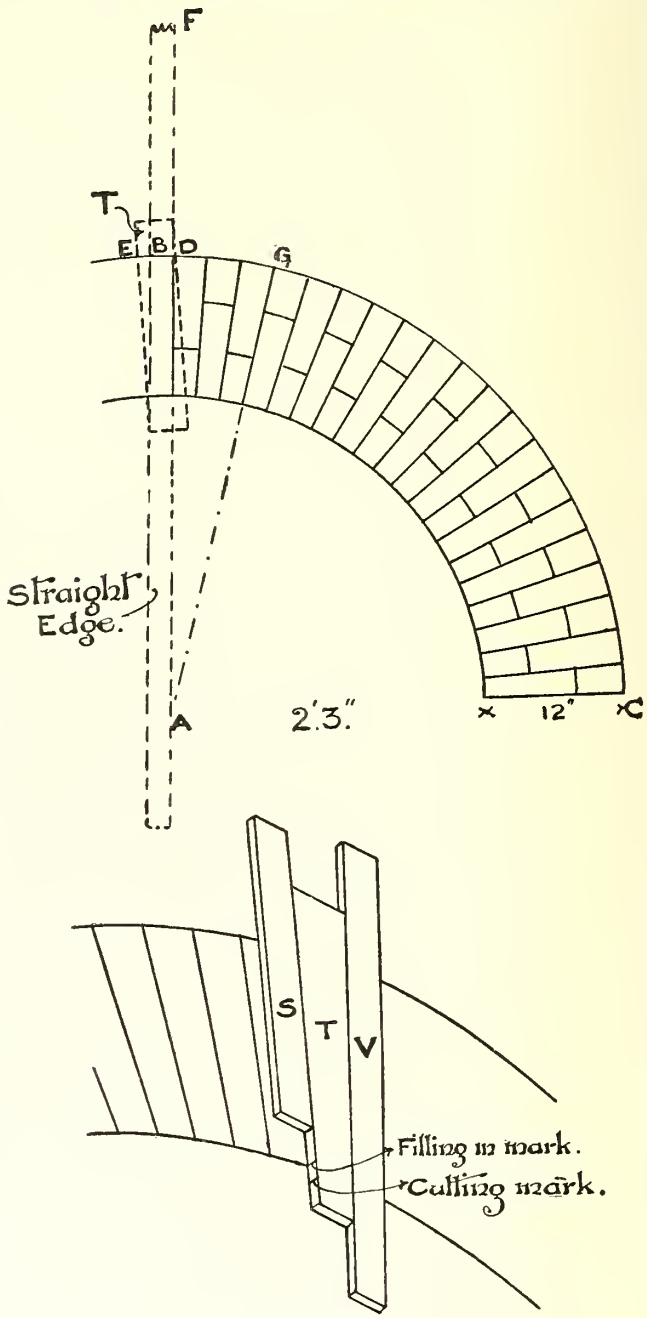


Fig. 183.

place the straight edge S against V, keeping its lower end above the intrados line. Remove V, place T against S with the filling-in mark on the intrados, and place V against T. Repeat this operation until the springing line is reached. If the edge of the template falls a little short of the springing line the filling-in mark must be

shifted a little towards the wide end of the template, and if the template slightly overlaps the springing line then the filling-in mark must be shifted a little towards the narrow end of the template. It may happen that the edge of the template overlaps the springing line obliquely, in which case a few shavings must be taken off the overlapping end. Every time the shape of the template or the position of the filling-in mark are altered the template must be retraversed, care being taken that it be started from a position symmetrical to the centre line of the arch. When the template has been finally adjusted it is once more traversed, and the joints are filled in and the bonding arranged, as shown in Fig. 183, noting that in the key the lowermost brick is a stretcher. Allowance has now to be made for the joints, which should, in good work, be $\frac{1}{3\frac{1}{2}}$ inch thick. To do this the template is placed over the key with the filling-in mark over the intrados, as in Fig. 183, and the straight edge S is placed against it. The template is then slid upwards along the edge of S until its opposite edge leaves the radial line by a distance of $\frac{1}{3\frac{1}{2}}$ inch. Mark the left-hand edge of the template with a pencil immediately over the intrados. This mark is called the *Cutting mark*, and the edge of the template bearing the cutting mark is called the *Cutting side* and the opposite side is called the *Bed*. The template is now traversed, for four joints, using the cutting mark as previously explained for the filling-in mark, when the bed or right-hand edge of the template should come $\frac{1}{8}$ inch away from the radial line AG (Fig. 183). If this distance exceeds $\frac{1}{8}$ inch the cutting mark must be placed a little nearer the wider end of the template, and if less than $\frac{1}{8}$ inch the cutting mark must be placed nearer the narrow end of the template. The bed is now placed along the radial line AD, with the cutting mark upon

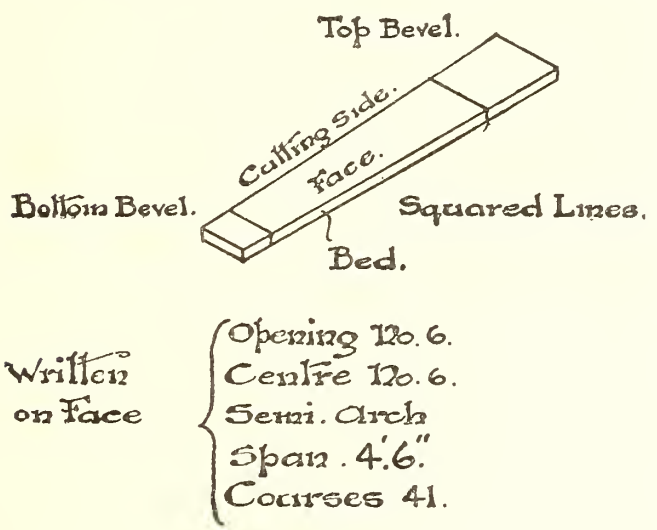


Fig. 184.

the soffit, and points are marked on its sides where the intrados and extrados come, and the four marks are squared across the sides and the extremities of these squared lines are joined across the face of the template, as in Fig. 184, thus securing the top and bottom bevels. The template is now complete, and it

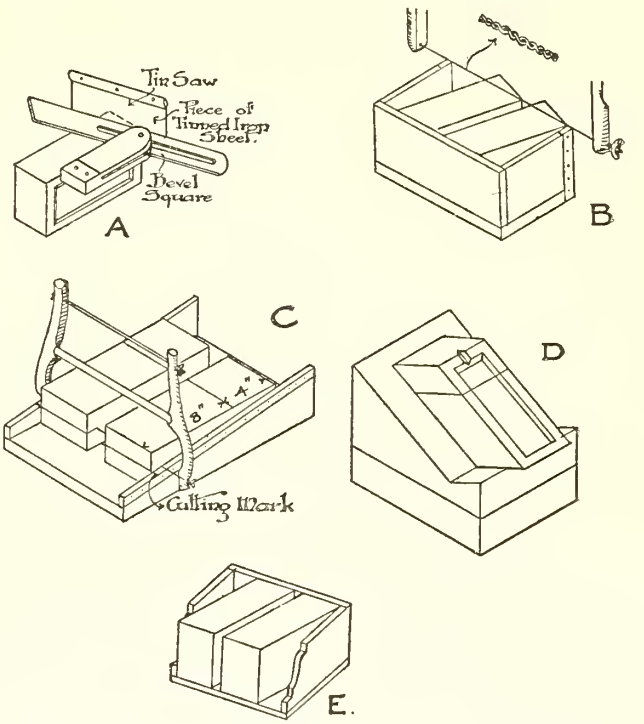


Fig. 185.

is a safe plan to write upon it its position in the building, the number of centre upon which it is to be stuck, the shape of the arch, its span and the number of the courses, as shown in Fig. 184.

Cutting the Voussoirs.—The bricks have now to be cut to the shape of the template, the operation of cutting being performed in the following manner: The bricks are bedded and faced in the manner shown for plain gauged work. The top bevel is then taken from the template with a bevel square, and the head of the brick is scribed to this bevel with a tin saw, as shown at A, Fig. 185. The ends of this scribed bevel are squared and scribed across the bed and cutting side of the brick, and the head is rubbed down to these lines. A wooden lengthening box is then made 8 inches in length, as shown at B, Fig. 185, and the bevelled head of the brick is placed tightly against the end of the box, and the end of the brick is cut off with a bow saw run down the open end of the box as shown. This gives the soffit bevel to the bricks. Boxes are usually made to take two bricks at a time.

The arch ring under consideration is 1 foot in depth, while the brick dealt with is only 8 inches deep, and must therefore be made up by 4 inches. To do this a $4\frac{1}{2}$-inch bat is taken, and is "bedded," "faced," and "bevelled" and cut off to 4 inches in length in a lengthening box. The 8-inch lengthening box already made will do for this purpose if a fillet of wood be nailed to its bottom 4 inches from the open end.

A radiating box C (Fig. 185) is now constructed, the sides of which, above the bottom, are shaped exactly like the template, and are placed with the cutting marks exactly opposite one another. The 8 and 4-inch bricks are then laid bed downwards in this box, and cut with the bow saw worked along the edges, and trimmed with a file.

Radiating boxes are usually made about 10 inches wide, so that two bricks may be cut at a time—one for the right hand, the other for the left-hand side of the arch.

The bricks are next laid upon a chopping-block (D, Fig. 185), and the frogs connected up and a cement channel cut in the upper end, the tool employed for cutting being a scutch (Fig. 174), which is formed of an old flat file sharpened at the end and fixed into a stock. If there be no frogs in the bricks the beds are cut out for cement joggles.

All the voussoirs of the arch are framed in a similar manner, and the arch is set over a centre.

Setting the Voussoirs. — Lime putty similar and similarly applied to the bricks as in plain gauged work is used for the joints, the grout channels being filled up with cement mortar when all the voussoirs are in position. The brick is then placed in position and lightly tapped to make it take a proper bearing.

Gauged arches should be built up from both sides, the key being inserted last, after which all the joints are thoroughly grouted up with cement and the putty trimmed flush with the face of the bricks.

Moulded Soffits.—To mould the soffit of a brick arch the above operations are only affected so far as the lengthening box is concerned. The two pieces of wood for forming the sides of the box are taken and screwed together, and the one end cut to the shape of the desired moulding. They are then separated and fixed exactly opposite one another at the sides of the lengthening box (E, Fig. 173). The bedded, faced, and bevelled bricks are placed in this box as before, and the ends are cut off to the shape of the moulding and trimmed, the straight parts with a file and the curved parts with a piece of gas barrel.

Segmental Arches.—The setting out and cutting of segmental arches is precisely the same as for semi-circular arches, but a small difference arises here in the cutting of the skewback. To cut the skewback accurately a wooden reverse called a *Gun* is made as shown in Fig. 176, the angle *cab* being equal to the angle formed by the jamb and the skewback, as obtained from the full size setting out. The gun is used in the following manner: The bricks from which the skewbacks are to be formed are laid dry in their places. The limb of the gun L is laid along the face of the jamb with the point *a* adjusted to the springing point of the intrados of the arch. The bricks are then scribed to the line *ab* removed and cut.

Flat Arch. — In flat arches (see Fig. 176) the method of setting out is somewhat different. The extrados and intrados are set out as before, the intrados being divided into the same number as the extrados. The only difference in cutting is that the bevels of each brick are different.

The skewbacks of flat arches are usually inclined to one another at an angle of 60 degrees, but a stronger arch is obtained if the skewbacks expand 1 inch for every foot in the width of opening.

All arches sag a little when the centres are removed, and sagging in the case of a flat arch is most unsightly, for which reason it is usual to give so called flat arches a rise of $\frac{1}{8}$ inch for every foot of span.

CHAPTER VIII

BRICKLAYING

In building brick structures the bricks are usually bedded in mortar, the function of this mortar being threefold:—

1. It unites the bricks together by its adhesion to their surfaces, thus causing the whole of a structure to act as a homogeneous mass.

2. It distributes the pressure evenly over the united surfaces of the bricks by filling up all the irregularities of these surfaces.

3. It fills up the joints of the brickwork, and thus prevents the penetration of moisture and the passage of the air, and so prevents any excessive changes of temperature within.

Thickness of Joints.—A clause very frequently introduced into a Specification is that no four courses of bricks together with four mortar joints shall measure more than one inch in excess of four courses of the bricks laid dry. This means that the average thickness of the mortar joints is $\frac{1}{4}$ inch. It is obvious, however, that the thickness of the joint

depends in great measure upon the regularity of the surfaces of the bricks. With common bricks it is usually essential to have joints at least $\frac{1}{4}$ inch thick, in order that there may be a cushion of mortar between every part of the surfaces united; while with bricks of better quality the joints may be less, even down to $\frac{1}{32}$ inch for carefully gauged work.

Methods of Laying Bricks.—The most usual methods of laying bricks, especially in walls of no great thickness, is that known as *Shoving*, which is performed in the following manner:—

Shoving.—A bed of mortar is spread with a trowel over the course of bricks last laid, and the quoin brick is carefully laid in position. The vertical edges which come on the face and end of the wall are *buttered*—that is to say, mortar is scraped on to these edges with a trowel, so that when the adjoining bricks are placed in position the vertical joints will be thoroughly filled with mortar at the outside ends. The adjoining bricks are next *shoved* into position with a downward sloping motion towards the quoin brick, so that the mortar oozes up into the vertical joints. It is then tapped with the handle of the trowel, and thus moved slightly in one direction or another until it exactly occupies the desired position, with its face vertical and flush with the surface of the wall, the mortar which oozes out of the joints on the face of the wall being scraped off with a trowel and thrown on to the interior of the wall. The next facing bricks are then laid, and the operation is continued until two or three feet of facings have been laid. The bricks on the interior of the wall are now laid, being shoved with a diagonal sloping motion against the facings and the last brick laid, this being necessary with the interior bricks so as to cause the mortar to ooze up into the vertical joint on two or three sides as the case may be.

Grouting is a process used when a fine joint is required, as in rubbed or gauged work. The bricks are laid in position on a bed of fine mortar, with the external edges of the facing bricks buttered. The interior bricks are then filled in, and the vertical joints are filled up with *grout*, *i.e.* mortar watered down to the consistency of cream and poured in from a can.

Grouting should never be used when the joints to be filled are large, as in that case there is a tendency for the sand to sink to the bottom of the joint.

Larrying.—In thick walls the most economical way of building is by a method called *Larrying*. In this the face bricks are first laid by the *shoving* method, the mortar being spread by means of a trowel. Hods or barrow loads of fairly liquid mortar are then tipped on to the interior of the wall and spread in a fairly thick even layer by means of a *larry* (see Fig. 174), and the interior bricks are shoved into position as already explained.

Wetting Bricks.—Bricks should always be wetted before laying, for two reasons:—1. To remove any dust from their surfaces. 2. To prevent them from absorbing the water from the mortar.

If there is any dust on the surfaces of the bricks the mortar will not adhere to them, and thus the strength of the work is considerably impaired.

If the water is absorbed from mortar it will not set properly, and it will crumble away.

If possible the wetting process should be performed by soaking the bricks in water, in a tub, for the space of 24 hours. Ample provision should be made, as bricks will absorb about one-sixth their weight of water, which is equivalent to one pint of water per brick, or 550 gallons per rod of brickwork. Less water is required when the bricks are sprinkled with a hose or dipped in a bucket, and generally a bricklayer has a bucket of water by his side when at work, in which he immerses the bricks for a short time before setting them in the work.

Protection of Brickwork.—It is very important that brickwork should be protected from the effects of the weather. It is better in frosty weather to suspend the work altogether, as the water contained in the mortar freezes and expands, thus weakening the work. There is danger, too, of a frozen wall buckling should the sun shine upon and thaw the ice in the joints on one face. Should it be necessary to continue the work in cold weather it should be done during the intervals between the frosts, and it should be covered with straw or sacks whenever the thermometer falls below freezing-point. When brickwork is built in Portland cement it may be continued in during a frost, as the cement sets before the water has time to freeze. If the wall is built in lime mortar the addition of about one-fifth of its bulk of quick-setting lime will enable the work to be carried on without danger with the thermometer well below freezing-point.

Rain and sleet without frost will not injure brickwork, but are actually a great advantage, as they thoroughly wet the bricks; but the tops of walls must be covered over with weather boards to prevent the water from running down the face of the work and discolouring it.

Face Joints in Brickwork.—A neat appearance is given to the mortar joint on the faces of walls either by *Jointing* or *Pointing*.

Jointing.—In jointing, the mortar in which the bricks are bedded is simply trimmed up as the work proceeds, as shown at A, G, Fig. 186.

Flat or Flush Joint.—This is formed by pressing the soft mortar, which oozes from the joints when a brick is bedded, flush against the wall with a trowel, as shown at A.

Flat Joint Jointed.—This joint, shown at B, is formed as a *Flat Joint*, and an indent is made along the centre of both the vertical and horizontal joints by means of a *Jointer* (Fig. 174) run along a straight edge or *Jointing rule*, as it is called when used for this purpose. Any strip of iron with a smooth edge may be used as a jointer.

Struck Joint.—In this the horizontal joints are

formed, as shown at C and D, by pressing or *striking* one edge back from the surface of the wall with a trowel. The vertical joints are usually made *flat*. The joint shown at C is a very good one, as the sharp line of shadow which it produces gives a pleasing effect, while at the same time it throws all rain water away from the joint. The joint shown at D is, on the contrary, a bad one, as it enables the water to lodge on the upper edges of the bricks. This freezes in winter, breaking away the edge, while in warm weather it soaks into the joints and causes the wall to be damp.

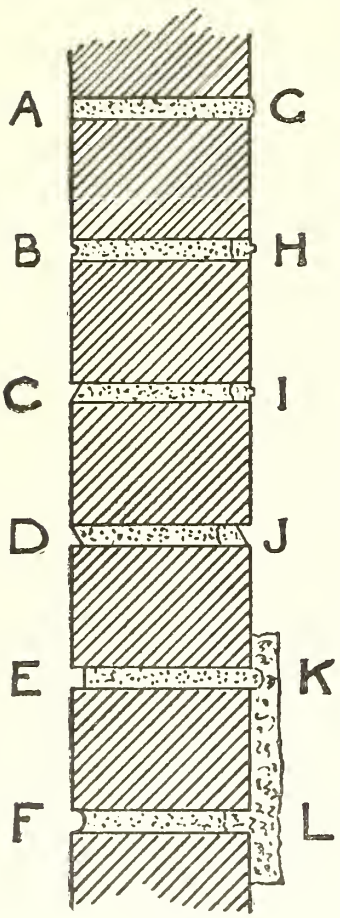


Fig. 186.

This joint has rather a pleasing effect when used in low walls built of regularly shaped bricks of a non-porous nature, owing to the sharp line formed by the upper edges of the brick, but this effect is lost at a height of a few feet above the eye level.

Recessed Joint.—When brickwork is built of non-absorbent bricks a pleasing effect can be produced by *recessing* the mortar joint back from the surface of the wall, as shown at E.

Keyed Joint. — This joint, shown at F, is formed by pressing the mortar back from the surface with a jointer of the width of the joint, having its edge moulded.

Mason's V-Joint.—This form of joint, which is shown at G, derives its name from its constant use for finishing the mortar joints of stone masonry.

Pointing.—In *Pointing*, the joints are raked out with a tool called a *Raker* (Fig. 174) to a depth of at least $\frac{1}{2}$ inch as the work proceeds, and then, filled with mortar *stopping*, starting with the top joints and working downwards as the scaffold is removed. The pointing is worked on the face of the wall in any of the methods shown at A, B, C, D, E, F, and G in Fig. 186, a pointed weather-struck joint being shown at J.

Tuck Pointing is the term applied to the operation of stopping the joints flush with cement or hard mortar, and running a fine line of white lime putty upon it, as shown at H.

After the stopping has been filled in the whole of the face of the work is coloured to the desired tint with a mixture of copperas (sulphate of iron) and a colouring pigment; or else the face of the brickwork is rubbed over with a piece of brick until the joints are the same colour as the bricks. Lime putty, composed of equal parts of lime and fine sand, with the addition of a little plaster of Paris, is forced on to the mortar joint with a jointer worked along a straight edge. The edge of the putty lime is trimmed with a knife with the end turned up at right angles, and known as a *Frenchman* (see Fig. 174), the putty being cut by the edge of this knife, and the superfluous material being scraped away by the turned up end. The putty line, when finished, should project about $\frac{1}{16}$ inch from the surface of the wall.

Its thickness is a matter of taste, but it is usually $\frac{1}{4}$ inch or less. Tuck pointing when carefully done is more than twice as expensive as ordinary pointing, but when roughly done it is frequently used as a cloak to hide excessively large mortar joints or other careless workmanship. It is frequently used to improve the appearance of brickwork in which the edges of the bricks have been destroyed by frost, but in no case can it be regarded as satisfactory, as the lime putty is slightly soluble, and is soon destroyed by heavy rains or discoloured by a smoky atmosphere.

Bastard Tuck Pointing.—This is the name given to a kind of pointing in which a projecting line of mortar is formed upon the stopping itself, as shown at I.

Keying for Plastering.—When brickwork is to be covered with plaster the joints are formed with the mortar projecting as at K, or they are raked out as shown at L so as to form a key.

Setting out a Building.—Suppose it is required to set out the building shown in Fig. 187. One corner of

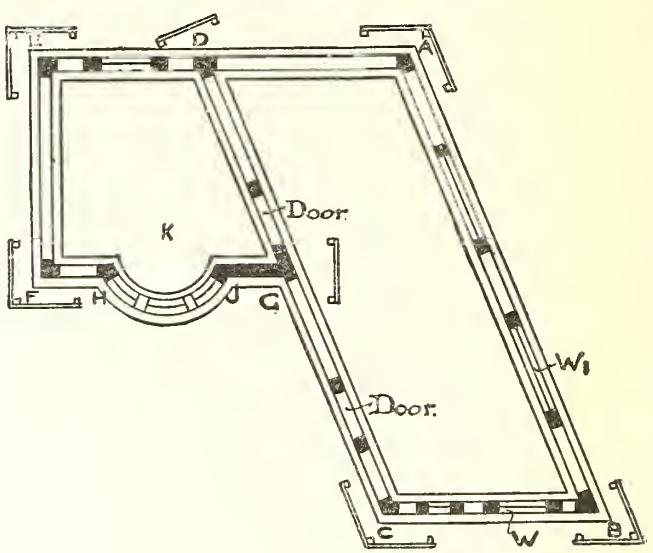


Fig. 187.

the wall, such as A, is fixed absolutely by measurement from surrounding objects shown on the plan, and a peg is driven into the ground, and a nail driven into the peg

to mark the exact spot where the angle occurs. The point B is now determined by measurement from surrounding objects (or the direction AB is set out with regard to the magnetic north, and the distance AB is carefully measured), and another peg is driven in at B. A line is stretched from A to B, and is used as a base line from which to set out the rest of the work. The line AE is now set out by measurements from A and B taken off the plan. The sum of these distances is marked on a piece of well-stretched cord. One end is held or tied at A and the other at B, a knot having been made at E (at the correct distance from A). Taking this knot in the hand, the string is tightened, and the point E is fixed accurately and a peg is driven into the ground at E. In a similar manner the points C, D, F, and G are pegged out. Angles are sometimes set out by means of wooden templates, and right angles may be set out by means of a tape held out into the form of a right-angle triangle, the sides being in the proportion of 3, 4, 5. The bow may be set out in two ways:—1. The points H and J are fixed by measurement along FG; then K, the centre of the arc, is fixed by measurements from H and J; at K a stake is driven

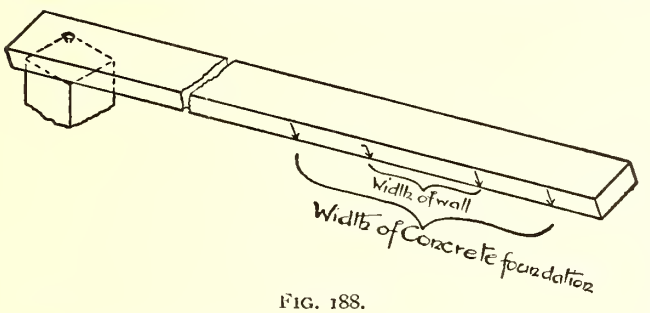


FIG. 188.

with its head just above the ground, and a strip of wood with a hole bored through one end is nailed loosely to the top of the stake, its nail being carefully placed so that its centre coincides with the centre of the arc to be set out. At the other end of the strip of wood marks are made corresponding with the thickness of the wall and the concrete foundations, as shown in Fig. 188.

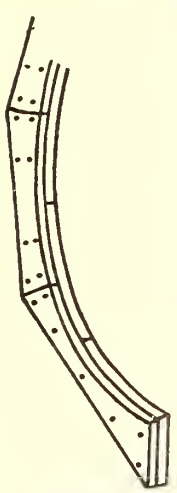


FIG. 189.

2. The points H and J are determined as before, and the curve is set out by means of a wood template formed as shown in Fig. 189. This method is essential when the curve of the bow is other than an arc of a circle.

Before commencing to dig the trenches all the main points should be most carefully checked by a number of measurements of the length of the walls and diagonals in every possible direction.

Where great accuracy is required in setting out, the best method of procedure is as follows: Peg out the main points of the building in the manner already shown, a fair degree of accuracy only being necessary. Wooden trestles of the nature shown in Fig. 190 are

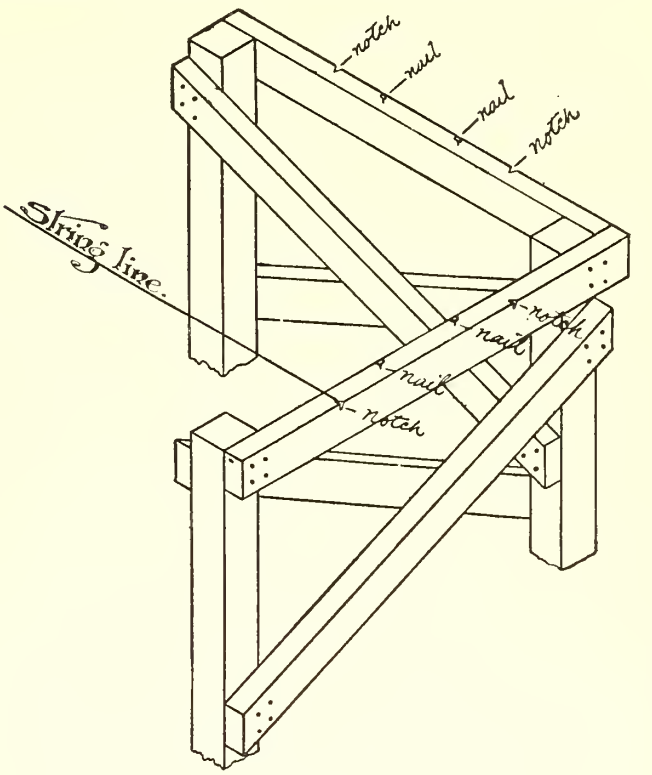


FIG. 190.

then erected near all these pegs, as shown in Fig. 187, and sufficiently far from them to be out of the way of the subsequent excavations. The horizontal bars of these trestles should all be at the same level and fixed quite horizontally. The uprights should be braced to prevent any chance of movement.

Lines are then stretched in the approximate positions of the outlines of the walls and foundation, and are carefully adjusted until the whole building is absolutely accurately set out in lines. Nails are then driven into the horizontal members of the trestles in the exact position of the lines representing the walls, while notches are made exactly under the lines representing the foundations.

COMMENCEMENT OF BRICKWORK. — All the angles, stopped ends, reveals, fireplaces, and all features needing special bonding are commenced first, great care being taken to place the bricks in the lowest course of the footings in such a position that these features may be built up in the exact position shown on the plans without destroying the bond. The arrangement of the bricks in the footings has already been explained. The parts of the plan shown in Fig. 187 which would be commenced first are marked in black.

Rule for Commencing Footings.—A rule for commencing the footings under openings properly, with a view to the quoin or reveal-headers falling in their

exact positions without destroying the bond, is as follows :—

Case I.—When the wall is an even number of half-bricks in thickness, commence the lowest course of the footings by laying two bricks as headers so that *their axes* come exactly beneath the desired position of the jambs of the openings, as shown at AA, Fig. 191.

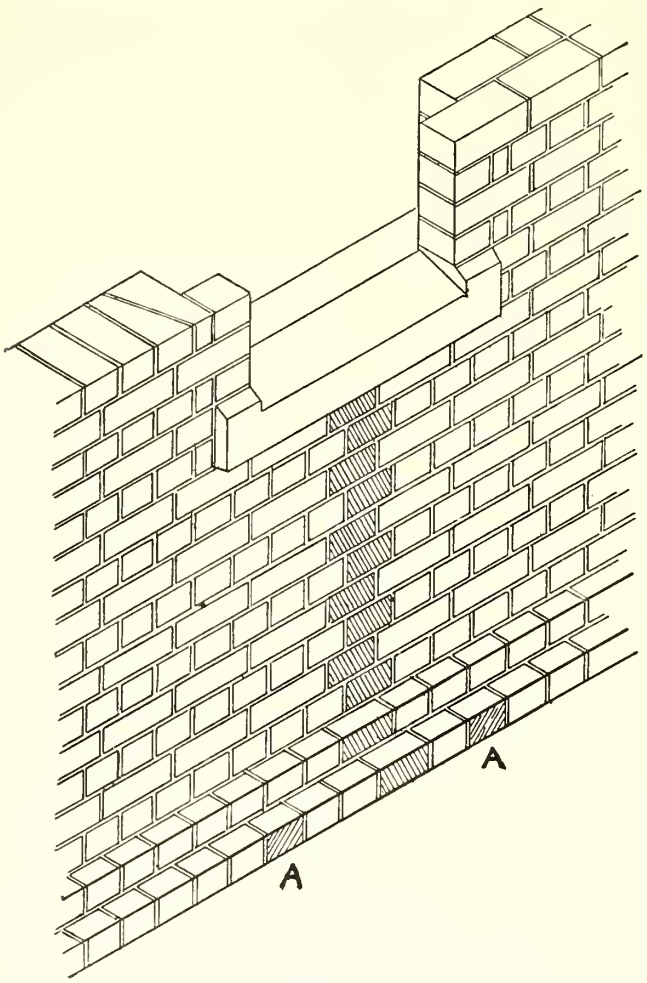


Fig. 191.

Case II.—When the wall is an odd number of half-bricks in thickness, commence the lowest course of the footings by laying two bricks as headers, so that *the edges of each* come exactly beneath the desired position of the jambs of the opening, as at BB, Fig. 192.

As already explained, when one wall meets another wall at an angle, the course which shows headers on the face of one wall will show stretchers on the face of the other wall. It follows, therefore, that the bricks in the footings beneath the windows W and W_1 (Fig. 187) will be different in their arrangement relatively to the position of the jambs. This difference will be accounted for by simply interchanging the terms in italics in the above two cases,—thus if the footings beneath the window W be started as described above, the footings beneath the window W_1 will be started according to the above rule with the words "their axes" substituted for "the edges of each," or *vice versâ* as the case may be.

The footings are now completed and the wall built up to damp-proof course level, care being taken that the courses are horizontal throughout. The wall should, if possible, be carried up evenly all over the site to ensure even settlement.

A piece of slate, tin, or zinc is sometimes inserted in the first joint above ground level at the *corners*, so as to form a projecting ledge upon which to rest the

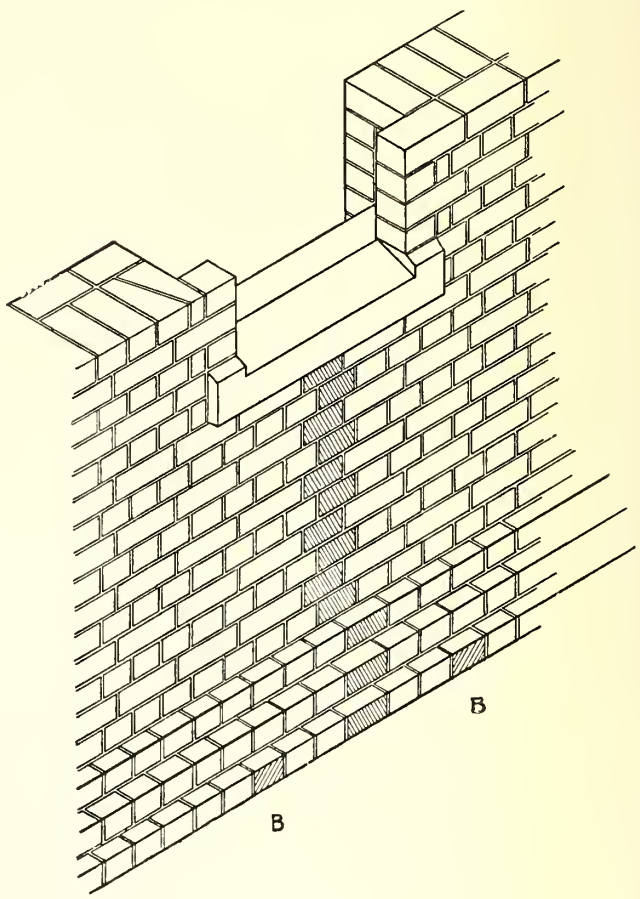
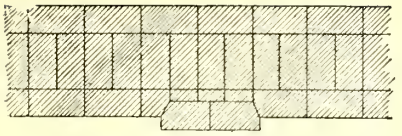


Fig. 192.

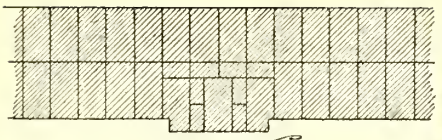
gauging rod, that is, a rod marked off in lengths equal to the depth of the courses, as shown in Fig. 174, care being taken that they are all at the same level.

Raking Back.—If any portion of the brickwork is delayed for any reason the *corners* or portions commenced first are built up, as shown in Fig. 193, each successive course being stopped short of the one below so as to form a stepped appearance. This is called *Raking back*, and its object is to prevent unsightly cracks from appearing, a defect which frequently occurs when the corners are *toothed*.

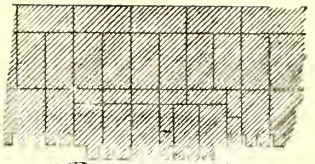
When new walls are being built the corners are built up in successive portions at a time, and the



Plan at J

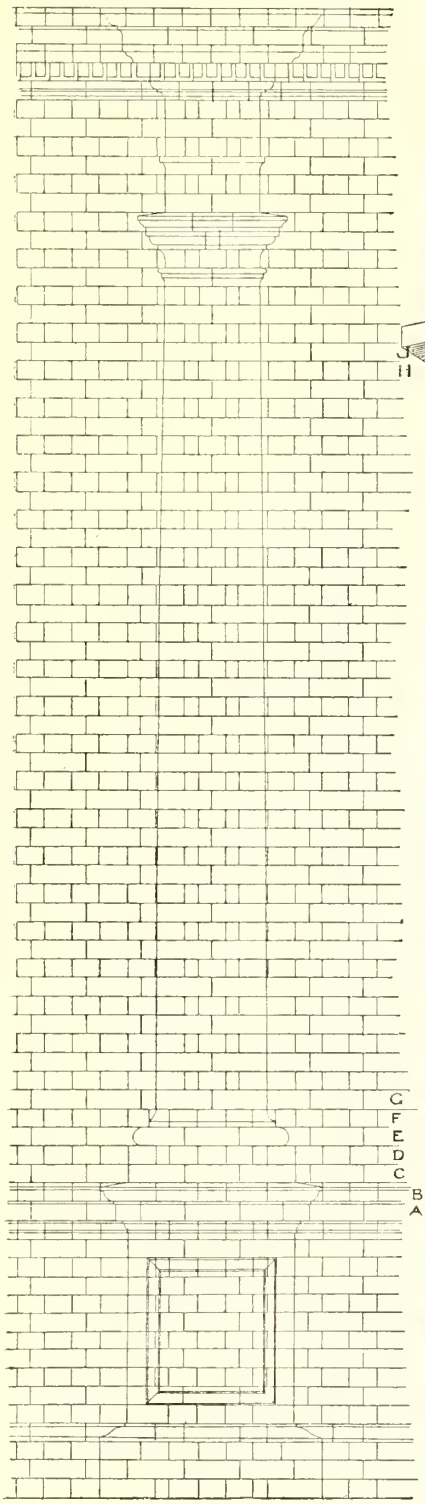


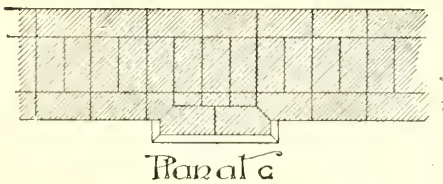
Plan at H



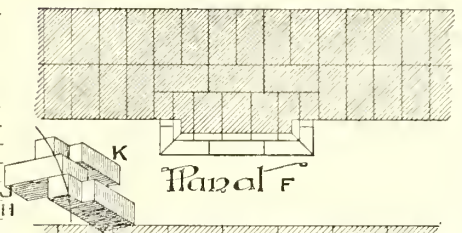
Plan of Dentil Course

Cut Brick Pilaster

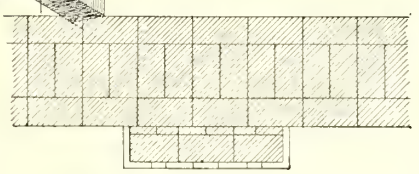




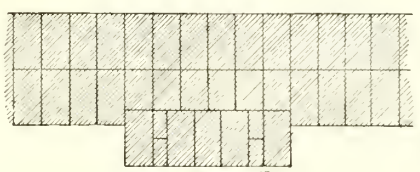
Plan at G



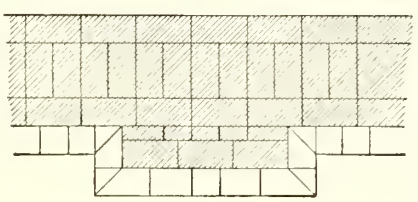
Plan at F



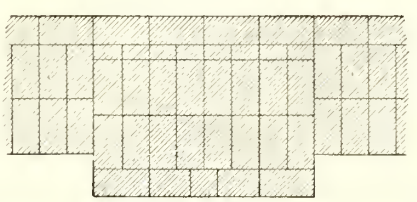
Plan at E



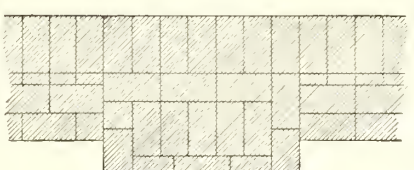
Plan at D



Plan at C



Plan at B



Plan at A

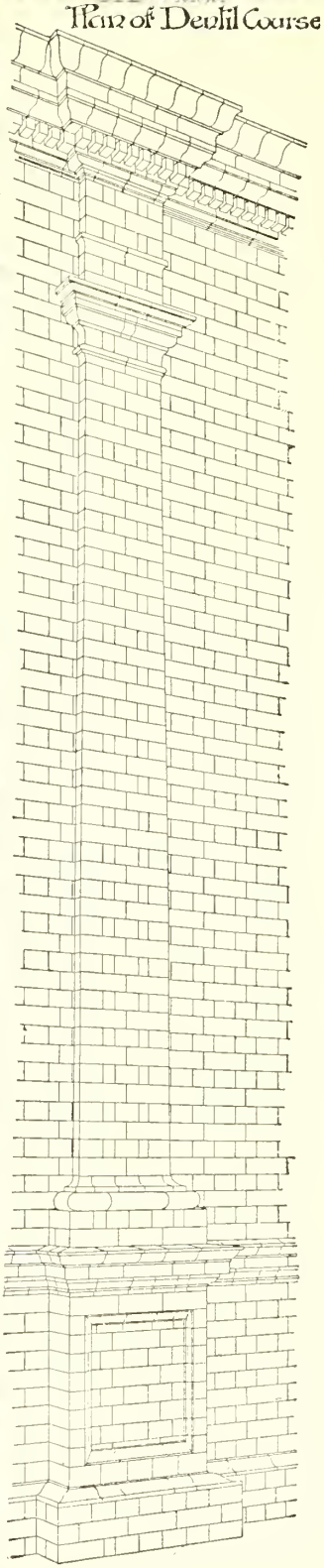


FIG. 196.

courses raked back as the work proceeds. The faces of the wall are very carefully plumbed with the *plumb rule*, as shown in Fig. 174. Lines are then stretched

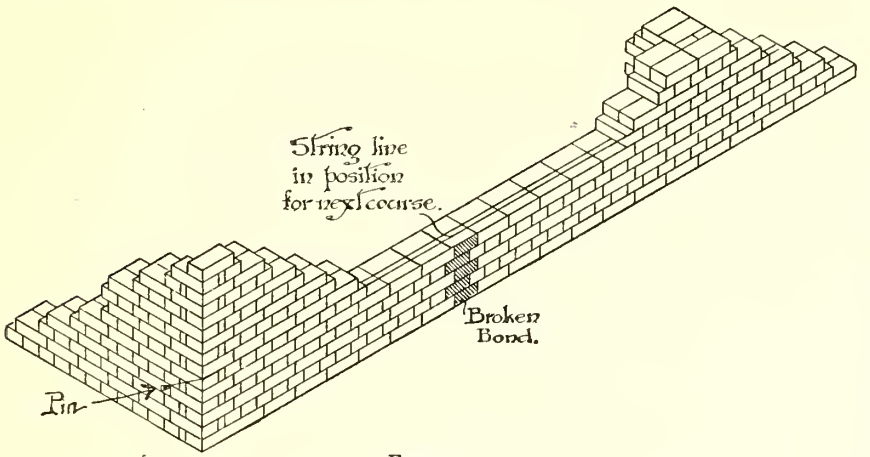


FIG. 193.

between the corners, and the intermediate portions of the wall are built up to the line, the courses being thus kept straight and level. The line is propped up at intervals if the corners are so far apart that it sags appreciably.

TOOTHING.—When it is desired to extend a building at some future time the walls are usually left *toothed*, so that the new work may be bonded to the old, and the whole appear as one continuous piece of work, the headers being placed to form the projecting teeth,

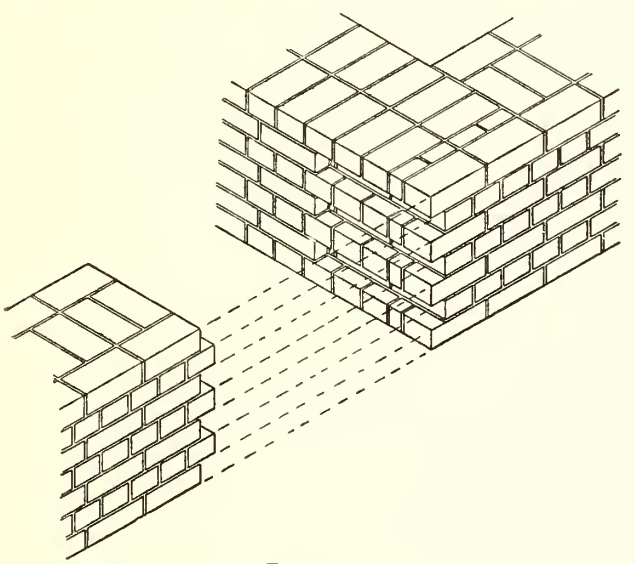


FIG. 194.

as shown in Fig. 194. When such provision has not been made a new wall is bonded into toothing formed by "drawing" the bricks of every other course of the old work, and bonding the new work to it as before. When a new wall is built on to an old one at any place other than an angle the old wall is toothed, as shown in Fig. 195, sinkings being made the whole breadth of the new wall, and the height of three or four courses, to a depth of $2\frac{1}{4}$ inches or more, according to the thickness of the old wall. The projecting portions between the sinkings should be at least three courses in width, otherwise the bricks will become loosened when the sinkings are cut. The cutting is performed by means of a *crowbar*, a *cold chisel*, *mash hammer*, or a *bricklayer's hammer*, all of which are illustrated in Fig. 174.

Whenever new work is bonded into old work the former should be built in cement mortar, to reduce the settlement to a minimum. As all buildings settle to a certain extent, it is better to connect new work to old by means of a chase cut into the old wall, so that the new work may settle independently of the old, as explained in Chapter I.

When old walls have to be broken away, or cut through for the insertion of doors or windows, the operation is performed by means of a *brick axe* (Fig. 174), the edges of the openings being trimmed with a cold chisel and hammer.

BROKEN BOND.—When the distance between two "corners" or portions first built does not permit the wall between them to be built entirely of whole bricks

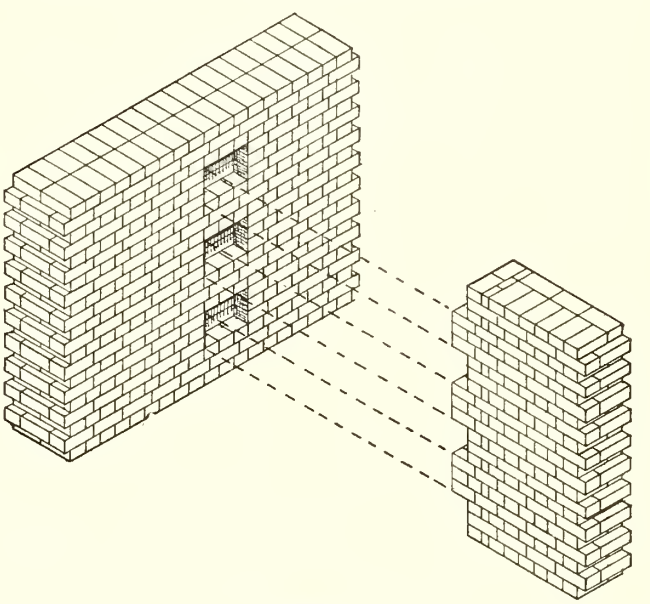


FIG. 195.

the bond will be *broken* at some point between the corners, bats of odd lengths being built into the wall, as shown shaded in Figs. 191 to 193.

ORNAMENTAL BRICKWORK.—Ornamental features are frequently constructed in gauged brickwork. The pilaster with its pedestal and cornice, shown in Fig. 196,

has been chosen for the purpose of illustrating the general principles of cutting and bonding.

Joints.—The general arrangement of the joints should, for appearance sake, be as symmetrical as possible.

Entasis.—The width of the pilaster is diminished towards the top, the return sides following a slight curve. This curve or *Entasis*, as it is called, is formed by first cutting the bricks to a rebate with all the faces square, the depth of the rebate increasing as the column diminishes in width. The bricks are built up with the side of the pilaster formed into a series of steps as shown at K, and the steps are rubbed off with a piece of brick or stone until the side forms the desired curve. At K the curve of the entasis is made exaggerated, so as to show the bricks stepped appreciably, but on referring to the elevation of the pilaster it will be seen that the curve, and consequently the amount of rubbing required, is very slight.

Mouldings.—The mouldings are all formed in lengthening boxes with the sides cut to the desired sections, as already explained. Mitres, both internal and external, should be cut out of the solid, and not formed of two bricks mitred together. If it is not possible to cut a mitre out of one brick, two pieces should be joined together in the following manner: Shake a strong solution of shellac in methylated spirit, and then pour the solution into water and stir it violently. This causes the shellac to curdle, and the curds are taken and spread upon the two surfaces of the bricks which it is required to unite. The bricks are then pressed together and left for the shellac to harden, when they may be cut with no fear of fracture across the joint. The projections of the mouldings is considerably restricted by the sizes of the bricks, no course projecting more than $2\frac{1}{4}$ inches beyond the course below. If possible all projecting courses should be headers, so as to tail well into the wall, and the upper members of a cornice should be built in cement.

Dentils.—The joints in the dentil courses should be arranged to occur immediately at the side of dentils, as they are very unsightly on their face, or on the face of the sinkings between them.

Dentils are cut in boxes similar to reducing boxes, with the side cut to the shape of the plan of the dentils. When a dentil course breaks round a projection a dentil may be arranged to come at the angle and appear on both faces, or two dentils, one on each face, may be arranged to intersect at the angle, as shown in Fig. 196. If dentils have to be cut out of small pieces they should be jointed with shellac on to one of the adjoining bricks.

Bonding.—As every course of the pilaster, pedestal, and cornice is different on plan, the bonding of the bricks must be specially arranged, as shown by the plans A to J, Fig. 196.

Carved Brickwork is usually executed upon gauged work, the bricks being left projecting from the face of the wall to an extent just sufficient to include all the desired carving. In cutting the bricks which are to be carved the labour of "facing" is entirely unnecessary.

CHAPTER IX

TERRA-COTTA WORK—FAIENCE WORK

Terra-cotta is the name applied to a material produced by burning any fine variety of clay which will vitrify upon the surface at a comparatively low temperature. The many advantages possessed by terra-cotta have caused it to become one of the most important building materials of the present day, and so, indeed, is it likely to remain unless the art of its manufacture is lost.

Terra-cotta lends itself well to all kinds of plain or decorated work both for the external and internal parts of a building.

As a substitute for stone it possesses many distinct advantages, chiefly in its weathering properties, there being many examples of terra-cotta which, in spite of many centuries of exposure to the atmosphere, are practically as perfect now as on the day they left the kiln, while the finest of stones similarly exposed have crumbled away.

Terra-cotta work is cheaper than stonework, particularly when features are frequently repeated in a design, and so only require one mould for a number of pieces. Moreover, terra-cotta is strong, and easily moulded or modelled to all shapes, while it can be made in numerous beautiful colours, and it is clean and sanitary, the two last properties rendering it particularly useful for smoky towns.

For building purposes terra-cotta is made into hollow blocks with shells about 2 inches thick, these

shells being stiffened when the blocks are large by means of webs to prevent them from warping or twisting when fired in the kiln.

The size of the blocks should be limited to about $3\frac{1}{2}$ cubic feet, but the smaller they are the less likely are they to warp in the firing.

To the manufacturer there are but three descriptions of terra-cotta, namely—Plain, Moulded, and Enriched.

Plain Terra-Cotta.—This is the name given to terra-cotta work which has plain faces only; that is to say, work which resembles plain ashlar work.

When building terra-cotta walls the hollow spaces within the blocks should be filled with concrete, very great care being taken that the cement or lime used for this purpose may not be hot, so as to expand on setting and burst the shell.

It is a mistake to use terra-cotta as a veneer only, as its strength in compression is very considerable, far exceeding that of Portland stone.

Walls faced with terra-cotta backed with brickwork are built in a similar manner to brick ashlar, the blocks being made to suit the dimensions of the particular brick employed, in order that a proper bond may be obtained. The blocks should be arranged to bond properly with one another, an arrangement similar to Flemish bond being satisfactory both in strength and appearance.

Moulded Terra-Cotta.—Particular care must be taken in making mouldings in terra-cotta in order that the blocks may be as straight as possible, as the smallest irregularities become very apparent when set in the work in continuous lines, such as cornices and string courses. If enrichments be added, however, irregularities become less noticeable, and as they scarcely add to the cost there is every reason for their employment.

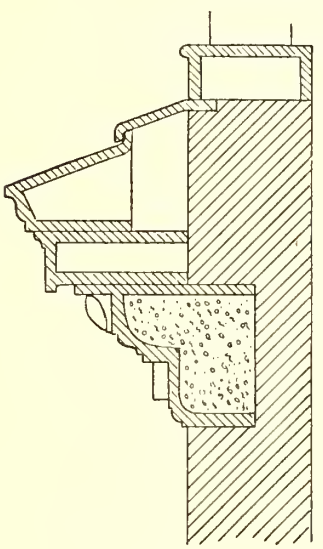


Fig. 196A.

When features of considerable projection are to be formed of terra-cotta the cavities in the projecting blocks are left unfilled, advantage being taken of their lightness to obviate the necessity of having counterbalancing loads to keep them from overturning. Fig. 196A shows how a cornice would be built in terra-cotta.

The lower blocks are filled in with concrete—lime concrete for preference, so as to give sufficient weight within the thickness of the wall to enable the upper projecting blocks to be stably supported. These are kept small by building them up as shown while they are left unfilled, and so are light to carry. The upper weathered surface is formed of a slab in preference to a block.

The tailed-in blocks can be further supported by means of angle irons resting upon them and running along the whole length of the cornice, these latter being anchored down at intervals by means of bolts passing down and terminating in iron plates built into the body of the wall. The blocks forming the balustrade, if there be one, are either filled up with concrete so that the weight may add to the stability of the whole, or supported by a light framework of iron. The method of fastening every part of the terra-cotta work should always be determined before the terra-cotta is made, so that holes may be made therein for the insertion of the fastening if these are to be of metal, but it is better to avoid them and trust to the weight of concrete filling to counterbalance any projections.

The upper surfaces of projecting mouldings should be weathered, *i.e.* sloped so as to throw off rain water, and if large they should be built up in pieces, the upper pieces overlapping the corner pieces as shown. The vertical joints should be made to overlap by moulding small projecting strips of clay upon one end of each piece to keep the water out of the joint.

Enriched Terra-Cotta.—This term is applied to work in which modelled ornament occurs, such as foliage or figure modelling. If a feature is decorated with undercut ornament it is usually modelled by hand, but if any enrichment repeats throughout a design a mould is made for it, and the undercut portions are worked upon the moulded clay.

Openings.—When openings have to be spanned in terra-cotta by means of an arch of considerable rise the blocks are formed into wedge-shaped voussoirs; but if the arch is flat the limited size of the block renders the use of a lintel out of the question, so that a flat arch must be formed, the voussoirs having their bed joints stepped as in Fig. 197 or joggled as in Fig. 198, to prevent them from sliding out of place.

Sills are sometimes formed in one piece, in which case only the ends should be bedded, otherwise the weight brought upon them by the jambs may cause them to crack at the middle. If the sill is built of a number of pieces the joints should be lapped to keep out the water, and the upper edge should be turned up and let into a groove in the under side of the wood sill, so as to form a watertight joint as shown in Fig. 197.

Setting Terra-Cotta.—In setting terra-cotta blocks care should be taken to see that each block is fixed in the exact position indicated in the key drawing supplied by the manufacturer, and when terra-cotta is used in connection with brickwork the latter should be set out with very great accuracy, so that the terra-cotta may fit into its place exactly.

Before filling the blocks with concrete they should

be thoroughly soaked in water, to ensure the proper adhesion of the two materials.

The Mortar Joints are usually about $\frac{1}{4}$ inch wide, but the width depends upon the regularity of the

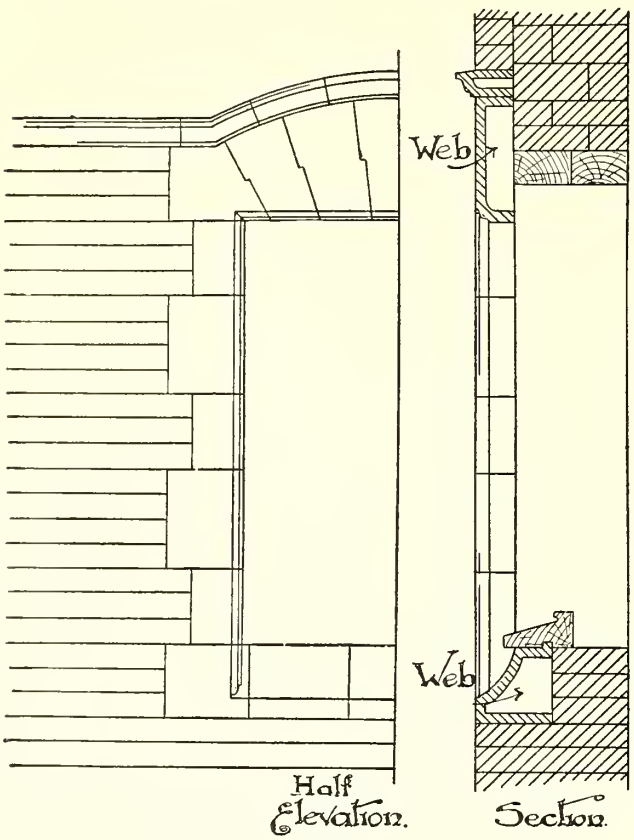


Fig. 197.

blocks, or upon the size of the blocks, which usually amounts to the same thing. A weather-struck joint is usually employed, as it prevents the accumulation of water therein.

The joints are sometimes raked out to a depth of about 1 inch, and caulked for about $\frac{1}{2}$ inch with oakum and finally pointed, so that should the mortar at the outer surface become disintegrated and so form a lodgment for water this cannot penetrate the joint.

Faience Work.—Faience is a form of glazed stoneware which is used considerably for building purposes. It can be made in nearly every imaginable colour, so

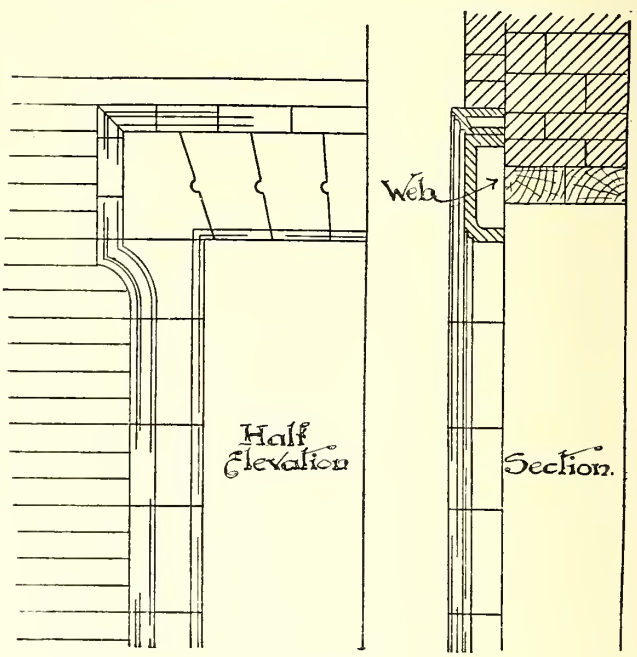


Fig. 198.

that a most charming effect can be produced. This material is particularly useful for use in smoky towns, where its colour adds a pleasing relief to the grimy surroundings, while its property of reflecting light has caused it to be used considerably for the facings of courtyards and open areas. Its application to buildings is similar to terra-cotta, save that it is usually made in larger pieces.

CHAPTER X

CONCRETE MASONRY

It is only in quite recent years that the custom of ancient Rome and Byzantium, of casting edifices in concrete, has come into use to any extent in England.

Engineers have for a long time realised the great constructive value of this material, but architects have considered it to be a material unworthy of their notice, chiefly on account of its poor appearance; yet there can be no reason why buildings in this material should not rival in beauty edifices in the handsomest stones.

Whatever the artistic value of concrete may be, there

remains no doubt that great economy may be effected by its use under some circumstances, and that its strength is considerably greater than that of masonry or brickwork, while its homogeneity makes it a far more suitable material for many purposes than any material of an aggregate nature.

Concrete Walls.—The method of constructing concrete walls is shown in Fig. 199. A large mould is formed within which to cast the wall. Boards from 1 to 2 inches thick are supported with their inner faces spaced to the desired thickness of the wall, against upright timbers, which on commencing a wall are supported by means of inclined struts. The uprights are arranged in pairs along the wall at distances of from 6 to 12 feet, and are bolted together at frequent intervals by means of iron bolts passing through wooden cones shaped to a conical form to facilitate their removal when the work

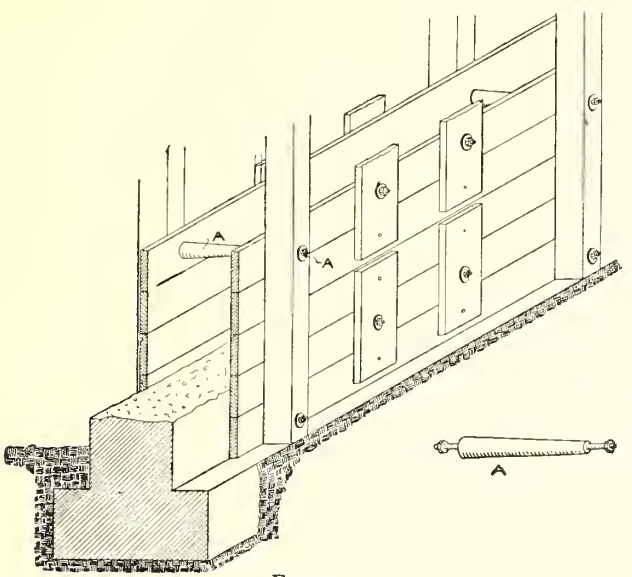


Fig. 199.

is completed. These bolts and distance pieces are illustrated at A, Fig. 199.

The planks which form the face of the mould are usually fixed together in groups of two or three, with their edges shot and placed close together. If the wall is to have a neat appearance their inner faces should be wrought. The boards or "shutters" are bolted together, and spaced by means of the conical distance pieces already mentioned, so that the face of the wall, when finished, may be true and even. The appearance of rusticated ashlar is sometimes given to concrete walls by nailing fillets of wood into the faces of the shutters, as shown in Fig. 200.

When the wall is carried up to such a level that the shutters and upright can no longer be supported from the ground, the latter are bolted at the lower ends through distance pieces higher up the wall, care being taken to set them perfectly vertically, and the work is continued as before.

Concrete Mouldings.—When mouldings have to be formed in concrete they are cast in wooden moulds built up of pieces of wood cut to the *reverse* of the

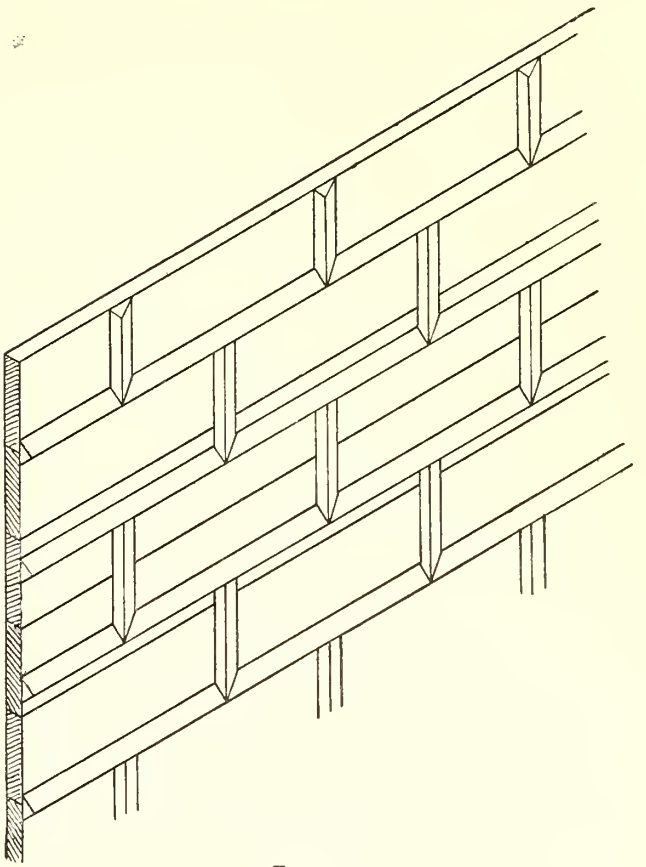


Fig. 200.

desired moulding and nailed at intervals on to stout support, as shown in Fig. 201. If the mouldings are undercut the moulds must be built up so as to take to pieces, and so enable the mould to be removed when the concrete is set. Undercut mouldings are best cast on to blocks and set in the building as ordinary building stones.

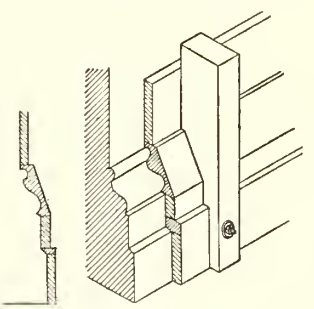


Fig. 201.

The interiors of moulds, the faces of shutters, and all fastenings which come in contact with the concrete should be coated with a solution of soft soap to prevent them from adhering to the concrete.

Cracks in Concrete Walls.—One of the great objections to concrete is that it often expands or contracts for a considerable time after it has been set in the work. When tested in a small quantity a volume of concrete may not appear to alter in size, but when a length of wall contracts all at once the total amount of movement may be very considerable, and cause unsightly gaps in the wall.

To guard against these disfigurements, wooden boxes are nailed on to the shutters at intervals vertically up the face of the wall, producing cavities in the latter as shown at B in Fig. 202. Above the centre of these cavities a piece of flat sheet iron of the shape shown at D (Fig. 202) is cast into the wall as at A. When the concrete has set the sheet iron is withdrawn, producing a vertical joint. If, now, the wall contracts sufficiently to cause it to crack, the opening occurs between the vertical joints formed by the sheet iron. When all expansion and contraction has ceased a block of concrete is fixed in the cavity with strong cement, and the vertical joints are flushed or grouted with cement, so that no disfigurement appears on the face of the work.

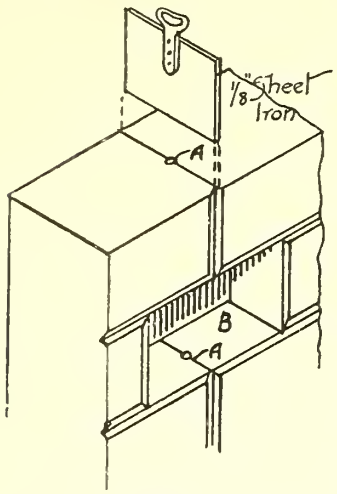


Fig. 202.

The Concrete.—The composition of the concrete depends upon the degree of fineness desired for the face of the wall. The strongest wall is produced when the aggregate is fine and hard, and has its interstices thoroughly filled with mortar. This condition will be fulfilled when the concrete consists of one part of cement, two parts of sharp sand, and three or four parts of fine aggregate. If the face of the concrete work is to have the appearance of stonework the aggregate should be broken up small enough to pass through a ½-inch mesh, and should be of an even colour; but when the wall is to be rendered, an aggregate in larger pieces forms a surface when set in the wall, which offers a better key to the rendering.

Mixing the Concrete.—The materials should be most thoroughly mixed for concrete walls, in order that they may have an even texture. The constituents of the concrete should be gauged upon a level wooden platform and turned over together twice with shovels while still in the dry state. The mixture should now be turned over twice more while water is sprinkled upon it from a rose, care being taken to water it uniformly.

Concrete is more thoroughly and more economically mixed in large quantities by means of a concrete mixing machine.

Laying the Concrete.—Great care should be taken when laying the concrete on the wall to make it come in contact with the mould in every place. To ensure this the concrete should be shovelled into position and rammed until it is thoroughly consolidated. The walls should be carried up evenly all over the site to prevent vertical cracks from appearing where the newer work is joined to the old, and this is done by laying the concrete in horizontal layers of from 9 to 8 inches deep. After ramming a layer the upper surface should be made rough so as to bond more thoroughly with the next layer.

Brick-Faced Concrete Walls.—Walls are frequently built with facings of brickwork and hearting of concrete. In Fig. 203 a wall of this description is shown, where the wall has been built up a certain distance in brickwork only, and then continued as a brick-faced concrete wall, with the facings composed of one row of headers and five rows of stretchers alternating, the headers on one face coming midway between the headers on the other face to ensure better bonding. The method of building up the wall above the plinth is as follows: Lay the first three courses of brickwork both at front

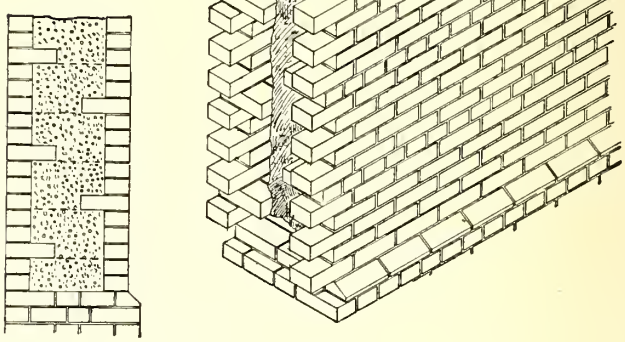


Fig. 203.

and back, and fill up the hearting to the level of the top course. Lay three more courses and level up the hearting, and so on until the wall is completed. It will be seen that each layer of concrete is 9 inches deep, which is a convenient depth for a wall of the thickness shown in Fig. 203. The reason why a deeper layer is not laid at a time is that it cannot be satisfactorily packed under the heading courses. The face may of course show any form of bond, but all the headers which tail into the wall should be kept at the same levels, so that the concrete may be laid in even layers while the headers, if any, in the courses between the tailing bricks should be *false* or "*snap*" headers. It is better, however, to adopt stretching bond, as shown in Fig. 202, for the five courses which intervene between the heading courses on each face.

Finishing Concrete Work.—When it is desired to give concrete walls the appearance of tooled masonry the face is roughly cut whilst the concrete is still soft,

and finished more carefully when it has set hard so as to give it the right texture.

Protection of Concrete Work.—Concrete work, when fresh, should be kept moist by plying a fine spray of water on to its surfaces in hot or windy weather, otherwise it will become covered with innumerable small cracks due to the imperfect setting caused by the evaporation of the moisture.

Armoured Concrete.—Concrete is now used largely in conjunction with iron, in which form it is known as *Armoured Concrete*, which will be dealt with in a later Volume of this work.

CHAPTER XI

STONE WALLING

It is possible to classify all descriptions of walls under three heads, as follows:—

1. Rubble.
2. Block-in-course.
3. Ashlar.

1. Rubble, on account of the variety of methods of coursing the stones, permits of the following further classifications:—

Uncoursed Rubble.
Irregular coursed Rubble.
Rubble worked up to Courses.
Regular coursed Rubble.

In rubble masonry generally the stones are irregular in shape and size, being dressed on face with a waller's hammer. In the best classes of rubble work the stones are sorted according to their shapes and sizes, and are dressed with the hammer to fit against one another with more or less vertical and horizontal joints, according to the quality of the work. In coarser descriptions of rubble work no selection of stones is made, the stones being placed upon the wall in the positions in which they fit best, the interstices being filled with small stones and spalls—small pieces knocked off rough stones with the hammer when dressing down their faces. Little or no attention is paid to the horizontality of the beds or the verticality of the joints.

The degree of regularity in rubble work depends in great measure upon the nature of the stone used. Stones of an intractable nature, such as basalt or stones of a crystalline structure, lend themselves best to rough rubble, while those which work more freely under the hammer are used for the more regular descriptions of rubble work.

As with brickwork, the facings of stone walls are laid first, their positions being indicated by means of strained strings, and the interior or *hearting* is filled in afterwards, care being taken to bond the whole together by means of *through* or *bond* stones at frequent intervals. Hollow spalls within the wall should also be thoroughly filled with spaces, and if there is any suspicion that this has not been properly done a trowel plunged into the work at intervals will reveal the fact. Care should also be taken when building the hearting that all the stones are large and well bedded, and that they do not act as wedges, which would cause the wall to split under its own weight. The quoins are usually formed of large stones more carefully bedded than the rest of the work.

Uncoursed Rubble.—In this class of work, which is also known as random, rough, or common rubble, no attempt is made to dress the stones beyond knocking off sharp corners and prominent projections. The stones are laid on the wall at random (see Fig. 204), with no attempt at coursing or at keeping the joints regular, the only tools required being a waller's hammer, a trowel, and a *plumb* or *battering rule*, as the case may require.

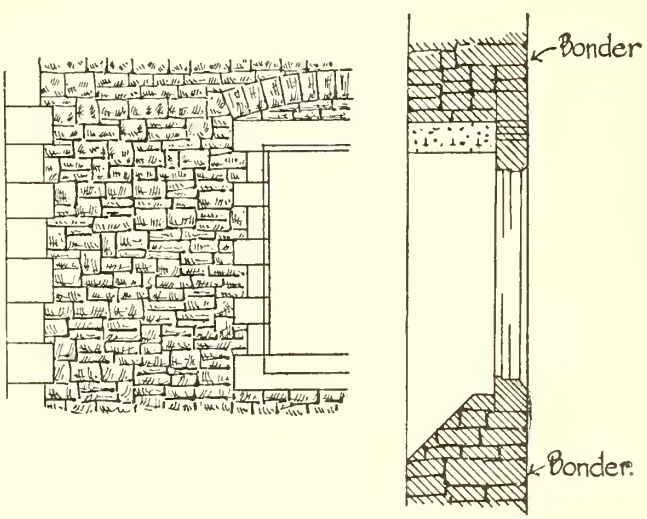


Fig. 204.

In walls of dwelling-houses one bond stone should be inserted for every yard super of the face of the wall, and should run from two-thirds to three-fourths through the wall. Bond stones should not run right through walls of dwellings, as they tend to conduct water to the interior. They should be placed alternately on either face of the wall, and be arranged in zigzag fashion, so as to distribute their effect more thoroughly.

A distinct variety of uncoursed rubble is built of flints, as shown in Fig. 205. Concrete or other firm

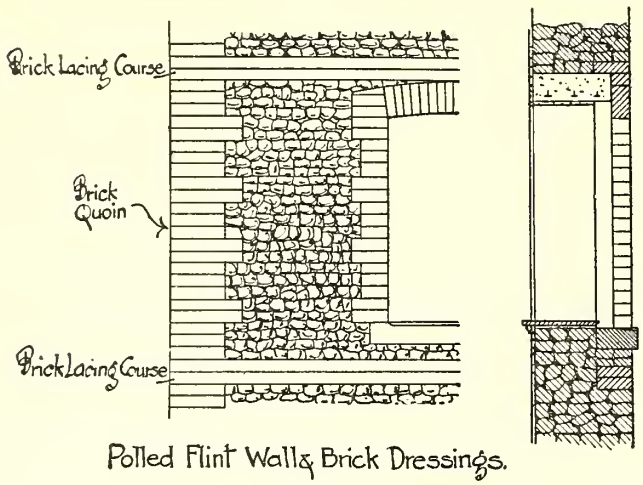


FIG. 205.

foundation is formed, and a wooden framework is then built up resting upon the foundation, the standards (Fig. 206) being carefully plumbed. Boards or *shutters*

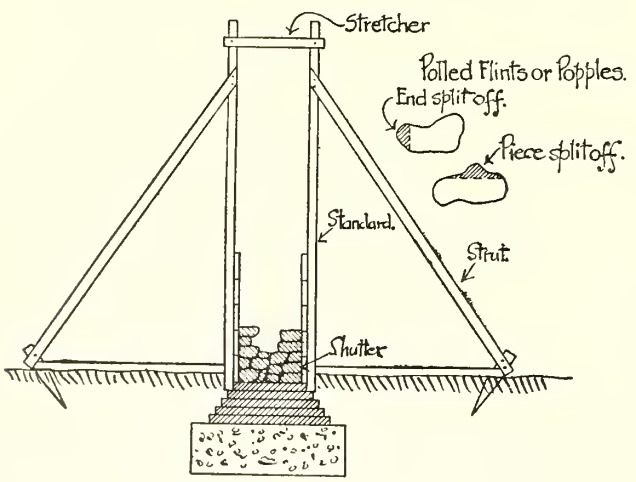


FIG. 206.

—as they are called when used for this purpose—are placed against the standards. The faces of the flints or *popples* are *polled* or split off, and are then laid with the polled face against the shutter. The face work is carried up, preferably in cement mortar, to a height of about 9 inches at a time, and the hearting is filled up in layers of about 4½ inches at a time, and thoroughly flushed up or grouted with mortar, care being taken to make the stone bond together. If a wall of this description is to be carried to any great height, the standards are bolted to the wall, as already shown for concrete walls. The quoins and dressings are usually built of some regular material such as brick or dressed stone, and lacing courses of brickwork or masonry are introduced at intervals of about 6 feet.

A variety of uncoursed rubble much used in ecclesiastical buildings is that known as *Rustic* or *Polygonal* work, which is illustrated in Fig. 207. In this description of masonry no vertical joints occur and no spalls are used on the face. Stones which occur naturally in shallow beds, such as Kentish rag limestone, are usually used for the face stones of polygonal work, the hearting being composed of brickwork. To fit any stone, such as S (Fig. 207), into position the

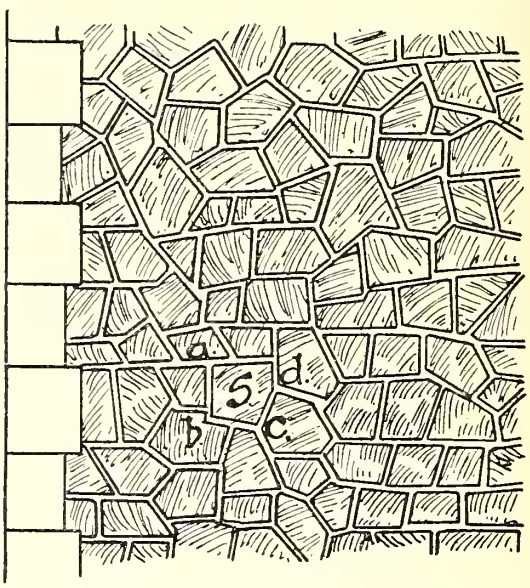


FIG. 207.

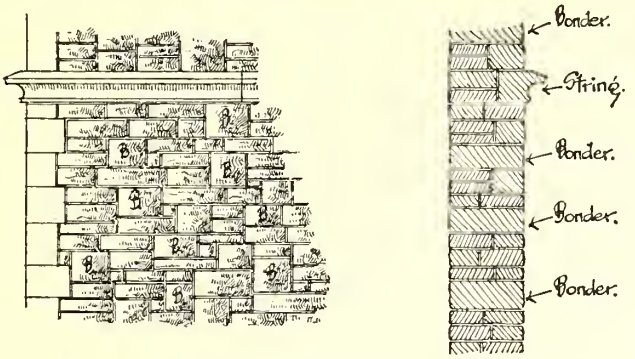
angles *abc* and *dcb* are taken with a bevel and marked upon a stone of suitable size, which is then carefully dressed to the three markings with a waller's hammer, the face being hammer dressed. This is an expensive form of rubble work, as it requires a considerable amount of skill and labour to make the stones fit with a close joint.

IRREGULAR COURSED RUBBLE, *or Snecked Rubble.*—When stones possess a distinct natural bed which varies considerably in depth, it lends itself very well for the class of rubble known as *Irregular* or *Random-Coursed Rubble* and more generally as *Squared* or *Snecked Rubble*. This (see Fig. 208) is usually built with the beds horizontal and the joints vertical, although it is by no means essential, depending chiefly upon the amount of labour required in squaring the stones.

The size of the stones should vary according to the

heaviness of the building, and a clause governing this point is often inserted in the Specification, such as, "No stone shall be more than 9 inches or less than 3 inches in depth."

The stones, as will be seen in Fig. 208, are built up to courses, which are broken at irregular intervals by



Irregular Coursed Rubble, Ashlar Quoins.

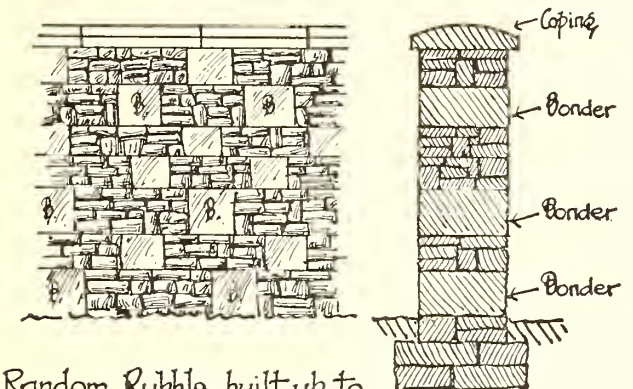
Fig. 208.

large stones, the length of these joints being governed also by a Specification clause, such as, "No horizontal joint shall be longer than 6 feet."

Small stones, called *Snecks*, are introduced at irregular intervals, marking the stopping of the courses and giving an overlapping appearance. The facings look best when hammer dressed or worked to any other rough texture.

The hearting of such walls is usually built of stones selected to form a proper bond with the face work.

Rubble built up to Courses is composed of stones built up to form straight horizontal joints at irregular intervals of from 1 foot to 18 inches, as shown in Fig.

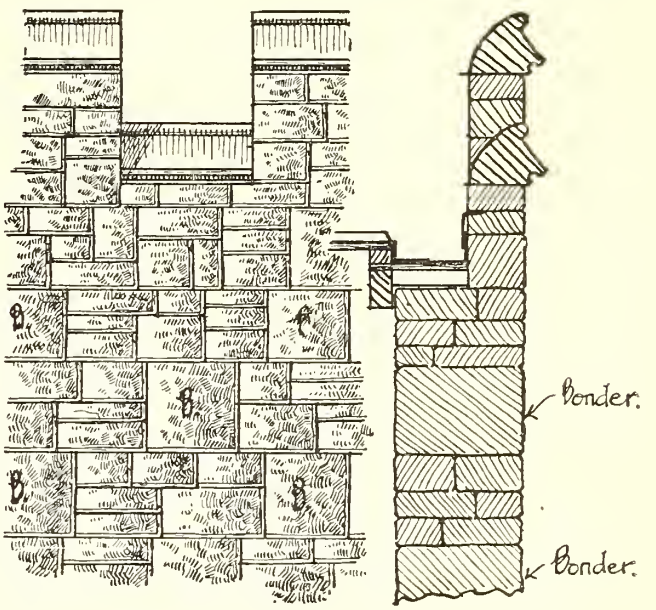


Random Rubble built up to Courses

Fig. 209.

209. The quoins and dressings are carefully dressed and laid with care to serve as gauges for the courses, lines being stretched between them, and the intermediate portions of the wall being built up to these lines.

When the stones are squared and the headers run the entire depth of the course, as in Fig. 210, it is sometimes termed *Coursed Header Work*, concerning which the following remarks of Professor Rankine[1] are well worth noting:—"One-fourth part at least of the face in each course should consist of bond stones or headers; each header to be of the entire depth of the course, of a breadth ranging from one and a half times to double that depth, and of a length extending into the building to from three to five times that depth, as in ashlar. Those headers should be roughly squared with the hammer, and their beds hammer dressed to approximate planes; and care should be taken not to place the headers of successive courses above each other, for that arrangement would cause a deficiency of bond in the intermediate parts of the course. Between the headers each course is to be built of smaller stones of which there may be



Coursed Header Work.

Fig. 210.

one, two, or more in the depth of the course. These are sometimes roughly squared, so as to have vertical side joints; sometimes the stones are taken as they come, so that the side joints are irregular; but no side joints should form an angle sharper than 60 degrees. Care should be taken not only that each stone shall rest upon its natural bed, but that the sides parallel to that natural bed shall be the largest, so that the stone may be flat, and not be set on edge or on end. Howsoever small and irregular the stones may be, care should be taken to make the courses break-joint. Hollows between larger stones should be carefully filled with smaller stones completely embedded in mortar."

Regular Coursed Rubble.—When rubble walls are built of stones occurring in shallow beds of regular

[1] Rankine, *Civil Engineering*, p. 386.

depth the method of regular coursing is adopted. When they are less regular in depth they are sometimes sorted into sizes, so that the courses may all be one stone in depth.

Dry Walling.—Picturesque boundary walls may be formed of any of the above kinds of rubble work laid without mortar, save polled flint or Kentish rag work, in which the adhesion of the mortar is essential to stability. Random rubble (see Fig. 211), or random rubble built to courses, is most generally used for this kind of work. Considerable care should be taken in bonding these walls, and in setting and pinning the unwrought stones. Dry walling should increase in thickness towards the bottom, the average thickness being about 4 inches for every foot in height of the wall.

Sometimes weathered copings are bedded on top of these walls, but more often the top is finished with a

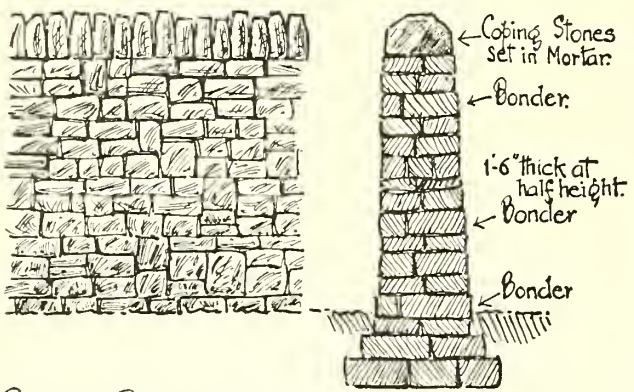


Fig. 211.

number of irregularly shaped stones, set on edge in mortar, puddled clay or even sods.

Mortar Joints in Rubble Work may be of any of the forms already shown for brickwork, the degree of perfection thereof being in accordance with the degrees of fineness in the working of the stones. When the joints are wide small chips of stone or pebbles are pressed into the mortar while it is yet soft. This is called *Galleting*, and although its appearance is rather pleasing it is not to be recommended, as it causes the joints to hold water and the wall to be damp.

2. Block-in-course.—When walls are required with a fairly fine face and of considerable strength a class of masonry known as *Block-in-course* (see Fig. 212) is employed.

The stones are squared and brought to a fine joint, while the faces are wrought to various degrees of fineness according to taste; but hammer dressing is most usual. The courses vary in thickness from 3 to 12 inches, but are chiefly built of *Shoddies* (stones less than 12 inches deep), and it is in this respect that brick-in-course masonry differs from ashlar.

Hard stones occurring naturally in beds of the above sizes are most suitable for this class of masonry. Chisel drafts are often run round the edges of the stones on face to enable close joints to be formed. Block-in-course masonry is difficult to define, as it closely resembles coursed rubble when no great amount of

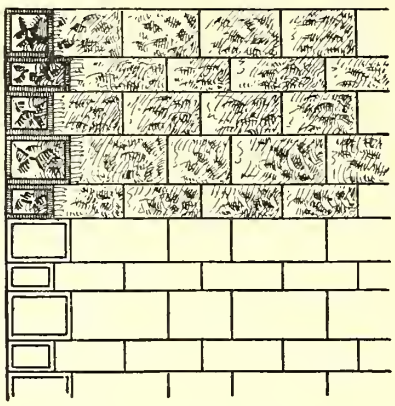


Fig. 212.

labour is expended upon it; while it resembles ashlar when it is more carefully wrought.

3. Ashlar is the term applied to the finest class of masonry, formed of blocks of stone usually over 12 inches deep, squared and worked to joints $\frac{1}{8}$ inch thick (see Fig. 213). Deep bedded stones are usually employed for ashlar work, these being sawn into blocks of the required dimensions. It is named according to the work

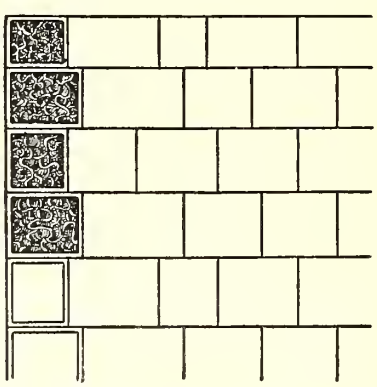


Fig. 213.

upon the face of the stone, which may vary in degree of fineness from *Quarry-Faced Ashlar* to *Wrought Ashlar*. When the face of the stones are rough, chisel draughts are run round the edges to ensure the close fitting of the joints. Every stone should be fitted into position before setting in mortar, and if the joints are not

sufficiently true to give a thin joint, the untrue sides should be taken out of winding. The beds and joints should not be worked too smooth, otherwise the mortar will not adhere to them properly.

The stone, having been properly trued and fitted in position, is raised off its bed and a bed of mortar is carefully spread for it; the edges of the stone are *buttered* as in brickwork, and it is carefully set in position again. The side joints are then grouted, the grout being worked about with a piece of hoop iron to ensure the joint being completely filled.

Brick and Rubble Ashlar.—It is very rarely indeed that walls are built entirely of carefully wrought stones. They are, as a rule, faced with ashlar work and backed with brick or rubble, as in Figs. 214 and 215. When brick backing is used the facings should be cut to brick dimensions, so that the work may be properly bonded, and the stones should be arranged like bricks in Flemish bond, the headers tailing well into the wall. The backs of the stones should be roughly squared to prevent awkward cutting of the bricks.

When rubble backing is used the rubble and the courses should be levelled up with the courses of the face work. The number of bed joints in the backing should be made as few as possible, as the extra number of joints in the backing will cause the work to settle unevenly. It is always better, therefore, to use cement or other quick-setting mortar for brick or rubble ashlar, so as to reduce this unequal settlement to a minimum.

Proportions of Stones.—Where squared stones are used for masonry work the length, depth, and breadth should be proportioned according to the hardness of the stone, in order to give it the maximum amount of strength. With the weaker sandstones and granular limestones the length should not exceed three

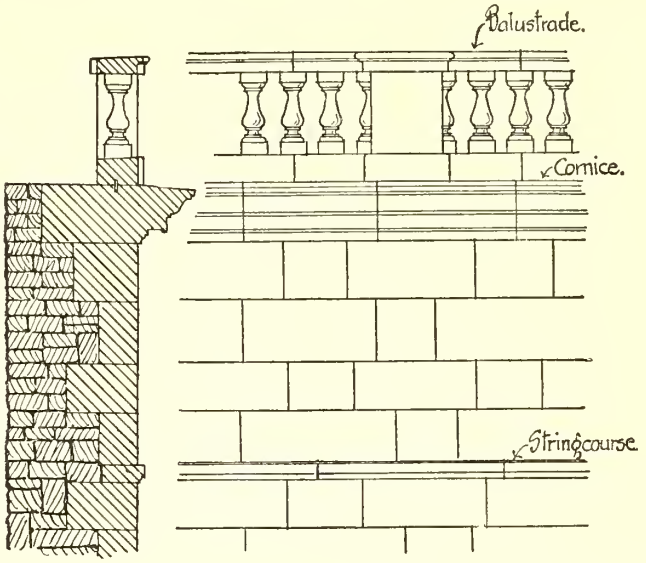


Fig. 214. Fig. 215.

times the depth, and the breadth one and a half times the depth, while with harder stones the length may be as much as four to five times the depth and the breadth three times the depth.[1]

[1] Rankine, *Civil Engineering*, p. 242.

CHAPTER XII

RUDIMENTARY MASONRY

(Contributed by W. Hooker)

Note.—The Science of Masonry and Stone-Cutting will be treated at length in another Volume of this work, but it is thought advisable to introduce here a few remarks of an elementary character, in order to render this Volume complete in itself.

The first step of the mason's foreman on receiving the Designs for the work is to calculate, by means of fully detailed drawings, the shapes and sizes of the various stones, with their measurements, for transmission to the quarry. This is effected by means of rules, set-squares, scales, compasses, etc., as detailed out in the following paragraphs. A list of the more common tools and levels, etc. will be also found in continuation.

The straight edge, usually of pear or other close-grained wood, is, as its name implies, of a perfectly straight face and of convenient length.

Set-squares of 45, 60 and 75 degrees are useful. Needless to say, the above should be carefully tested for accuracy.

Compasses, large and small; and also beam-compasses or pointers clamped to a hard-wood lath, and capable of being adjusted to any convenient length.

The usual scales, proportionals, and French curves, as well as a protractor, for setting off angles.

Most masons make their own sweeps, generally of clean deal or other suitable wood planed down thin into strips and carefully trued up, nailed together with a tie of the same material as the angle, and fixed at the intersection of the crossings. The guide

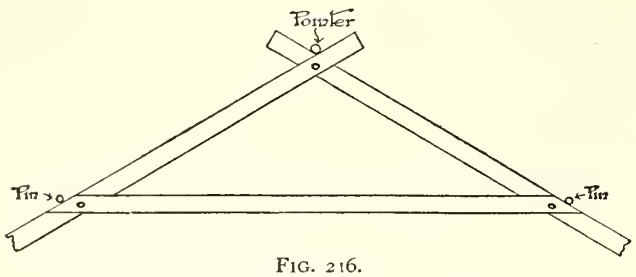


Fig. 216.

points are ascertained by calculation. The pencil or steel scribe is held firmly in the angle formed by the crossings, and by a lateral movement (the sweep being kept hard against the pins) a curve of the desired shape is formed (see Fig. 216).

It is presumed that the rudiments of geometry are known. At the same time, a few solutions of useful problems may not be out of place.

Problem I.—To divide a line into any number of equal parts, as, for instance, to divide AB into six equal parts (see Fig. 217). Draw AC at any convenient angle with AB, and mark off six equal parts with the dividers as 1, 2, 3, 4, 5, 6. Draw BD, making angle ABD = BAC, and from B mark off equal parts as before. Join 6-A, 5-1, 4-2, 3-3, etc., cutting AB in 1′, 2′, 3′, 4′, 5′. AB is divided into six equal parts. There are other methods of solving this problem.

Problem II.—To divide a line CD proportionally to the divisions on a greater or less line AB. Let AB be a greater line than CD, and let it be divided unequally in points 1, 2, 3, 4. Draw CD, and at C draw angle DCF, making the line CF = AB. Mark off on CF the points 1, 2, 3, and 4 equal to 1, 2, 3, 4 on AB. Join FD, and from points 1, 2, 3, 4 draw lines parallel to FD, cutting CD in 1′, 2′, 3′, 4′; CD will be proportionally divided to AB as required.

Problem III.—To set out a line in proportionate parts, *i.e.* diminishing in regular ratio. Let the line AB be required to be divided into twelve parts, diminishing towards the top. Take any convenient point C, and join AC, BC, making an angle of 35 or 40 degrees. Set off on a straight edge twelve equal parts, the total length being less than AB. Range this askew across the lines AC, BC until the extreme points 0 and 12 coincide with the lines, and prick off the divisions 1, 2, 3, 4, etc. as shown. Draw radiating lines from C through the points 1, 2, 3, 4, etc., and produced to AB. The points of contact 1′, 2′, 3′, 4′, etc. on line AB will mark the divisions required.

Problem IV.—When any two converging lines are given whose point of junction is inaccessible, to draw a line that would bisect the angle which would be formed by the converging lines. Let AB and CD be the two converging lines. Take the point E on AB and draw any line EF, cutting CD in F. From F draw FG cutting AB in G, and making the angle DFG = angle BEF. Bisect angle EFG by the line FH. Bisect FH in J, and draw KL at right angles to FH. KL if produced will bisect the angle formed by the converging lines.

The above are problems which are useful in setting out. The method of drawing arches, ellipses, and parts of conic sections, with their developments and projections, will be described in a subsequent Volume.

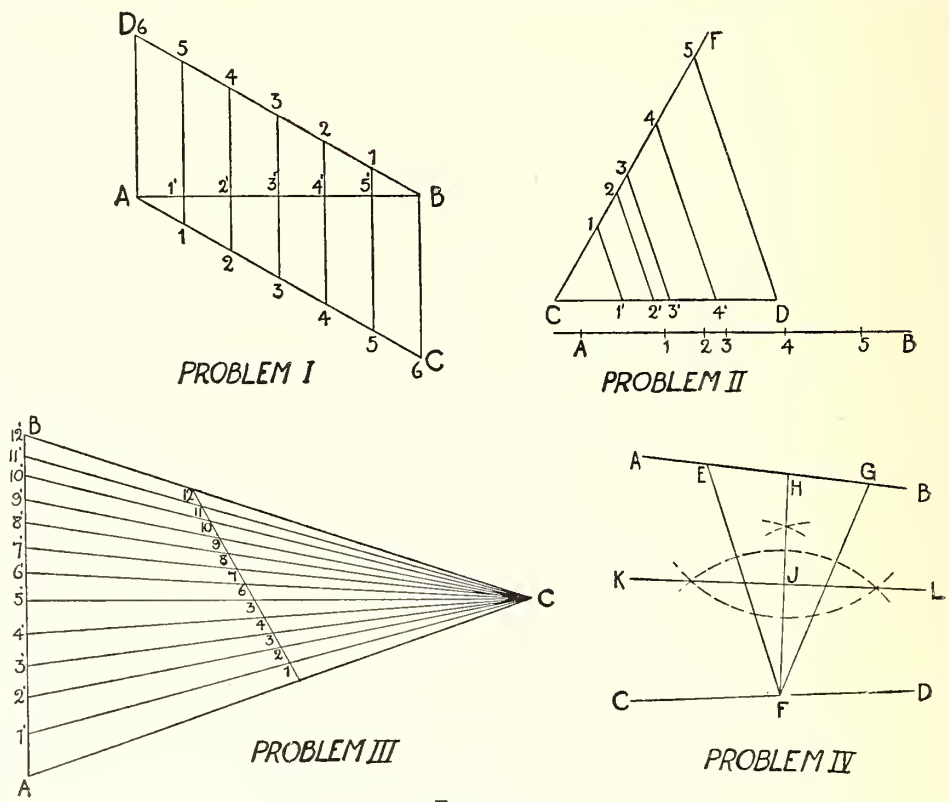


Fig. 217.

Tools.—The tools of a mason are: Various sorts of

chisels for dressing the stone, of different widths and sections, from the fine pointed chisel to the broad tool for droving or finishing, generally ranging from $\frac{1}{4}$ inch in width up to 3 or 4 inches; mason's picks for scappling; spalling hammers for rough dressing; wedges of iron or steel; feathers or slips of iron of a concave section; lewises and other devices for lifting and handling the stone; dividers for gauging the work; metal straight edges, angles, and bevels. The latter (bevels) are very important, as upon their accuracy depends the finished work. Bevels are of several varieties, and are generally set out by the mason to suit the particular work in hand.

Straight bevels require no explanation.

Twisting bevels are of various angles, and are set out from full-sized drawings made to scale for the particular stone requiring them.

Winding strips are bevels (see Fig. 218) for gauging the surface when required to twist (*i.e.* out of winding).

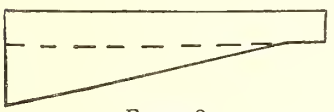


Fig. 218.

Dihedral bevels are required for setting out the angles formed by the junction of two plane faces. Templates are required for setting out the curves of soffit and extrados of an arch stones, and are struck to centres, or from the curves from which they are generated. Spirit-levels are necessary for setting up and trueing the work. Standards or rods divided into equal parts are used for marking off the courses of the stonework.

Quarrying.—The best beds of the several varieties of stone are always specified for good work, the picked stone being reserved for moulded stones, arches, cornices, etc.

The mode of "getting" the stone varies in accordance with the nature of the material. Some stone is blasted, other sorts are picked and split up by wedges, other sorts again are capable of being split along the planes of cleavage.

The stone thus procured is then rough hammer-dressed, picked or sawn to the sizes or scantlings ordered.

When it reaches the "banker" on the works the mason proceeds to "dress" the stone, usually commencing with one of the beds. The necessary dimensions being fixed on one surface, drafts are chiselled along one or more faces and tried by the bevel or square. These being found correct, cross drafts are worked, and the intervening rough stuff is knocked off and worked down with the tool until the surface is perfectly true and on a plane. The other faces are treated in the same way until a perfectly square or rectangular solid is formed.

For curved and twisted surfaces the faces are brought to the square as above, and the curved or twisted faces marked off with templates or bevels and the stone brought down to the required shape, as in Fig. 219, which shows the squared surface by the dotted lines, the firm lines giving the twist or bevel required for the finished work.

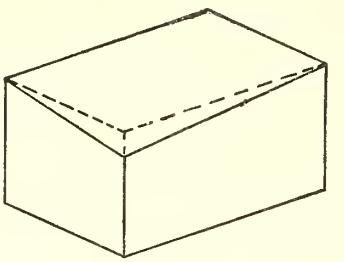


Fig. 219.

For mouldings a section of the mould is cut out in zinc or other metal and applied to the ends of the dressed stone, which is indented or marked with a steel pointer to the required profile. A diagonal draft is first cut to an angle coincident with the extreme edges of the mould, and then the mouldings are cut down to the finished shape (see Fig 220).

1 represents the finished moulding; 2 represents the rough angles enclosing the moulding; and 3 shows

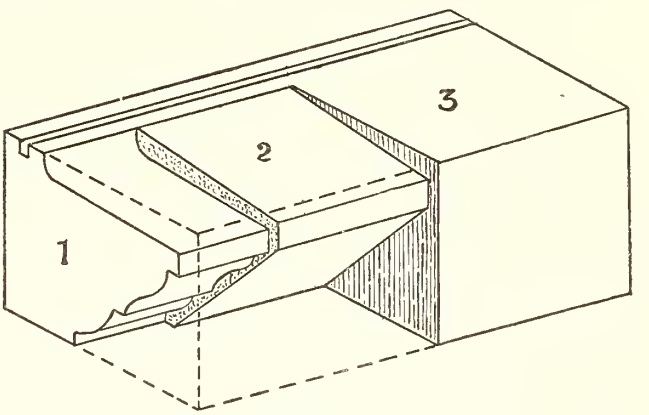


Fig. 220.

the square stone before the process of cutting the moulds is commenced.

In the case of curved surfaces, such as a semi-cylindrical coping, the stone is first brought to the form of a rectangular block with the height of the

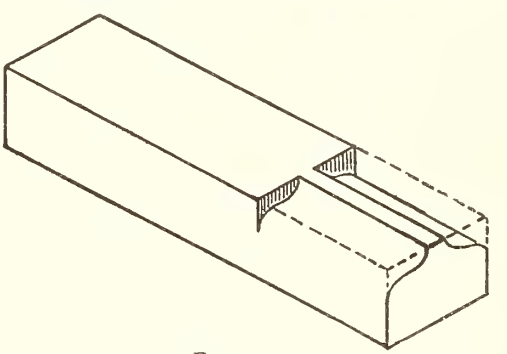


Fig. 221.

apex of the tabling of the curve. Straight drafts are then run from end to end of the stone at regular distances from the apex, coinciding with the section scribed on the ends; the intervening irregularities are then knocked off and brought to surface. Here the frequent use of the square and bevel is very necessary

to ensure good and accurate workmanship (see Fig. 221).

For arches or curved work the voussoirs are usually marked off in the rough stone, reversed alternately, and then sawn down diagonally almost to the sizes required. If care and judgment are exercised in this operation at least one of the sides of each stone can be utilised without further preparation (see Fig. 222), where the voussoirs 1, 3, 5 are reversed, while those numbered 2 and 4 are normal, the sawn joints *a*, *b*, *c*, *d*, *e* being finished, or with very little need of further treatment.

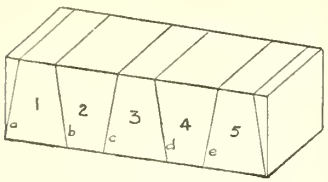


FIG. 222.

Faces of Stones.—There are several methods of finishing surfaces of stones for the building, and in a measure they depend on the nature of the material to be operated on.

In sandstones a chiselled face is usually considered the finish, although in the softer varieties the comb or drag is sometimes run over the surface to give a smoother effect.

In hard limestones such as Purbeck, Portland, etc., or in the case of grits such as those of Yorkshire, the claw tool is often used. For marble a small chisel with a slightly concave cutting surface is used to give a very smooth effect. Soft stones of a more crystalline nature, such as Bath stone and other oolites, receive a very even surface by means of drags of varying fineness, which remove all marks of the tool, leaving the face perfectly homogeneous. Droving leaves the surface in more or less regular parallel lines diagonal to the arris of the stone (see Fig. 223). Tooled work is

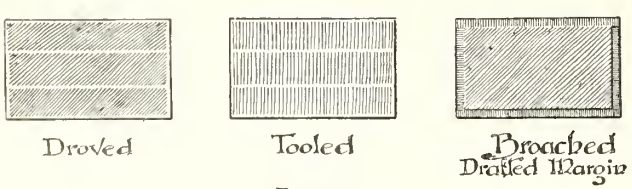


FIG. 223.

generally square with the arrises. Ashlar is similar to tooled work, but in continuous lines across the face and parallel. In section it gives the appearance of small concave curves.

Some work, especially for quoins and angle stones, is tooled on the margins, and picked, punched, or broached as desired in the central portion. Rusticated work has a tooled margin, and the centre cut out into an irregular pattern, of hollows sunk below the plane surface from $\frac{1}{4}$ to about $\frac{1}{2}$ inch. Vermiculated work is similar in many respects to rusticated, and needs no special comment.

There are other labours peculiar to granite, such as hammer blocking, bushing, tooth-axing, etc. Granite is also capable of a high degree of polish.

Setting Out, etc.—The ordinary type of buildings composed of enclosing walls with the usual apertures for access and light present no difficulty in setting out. It is in such cases as curved surfaces, niches, groined vaults, domes, or wing walls that great skill and care are requisite, and these will be treated fully later on.

The usual method employed by the masons is to lay out, on a platform of boards secured to prevent movement, an elevation (or part thereof) of the structure, with the beds and joints accurately divided off as shown by the small scale drawings and details provided by the architect, allowance being made for the thickness of mortar joints, etc.

Each course should be numbered consecutively by roman numerals, and the several stones in each course by arabic figures. These numbers should be marked on the stones when received from the quarry, and before sending to the banker, and the same numbers should be retained throughout the work. Care should be taken to distinguish between face and angle or quoin stones. Sills, plinths, strings, cornices, copings, etc., etc. are separately marked and kept distinct, as are also the moulded jambs, mullions, heads, transoms, and tracery stones of windows, doors, etc., together with hoods, panels, arches, niches, and all enrichments.

Plinths, plain or moulded, are dressed to the scantling lengths, the rake of splay set with a template from the details, and worked to the face required.

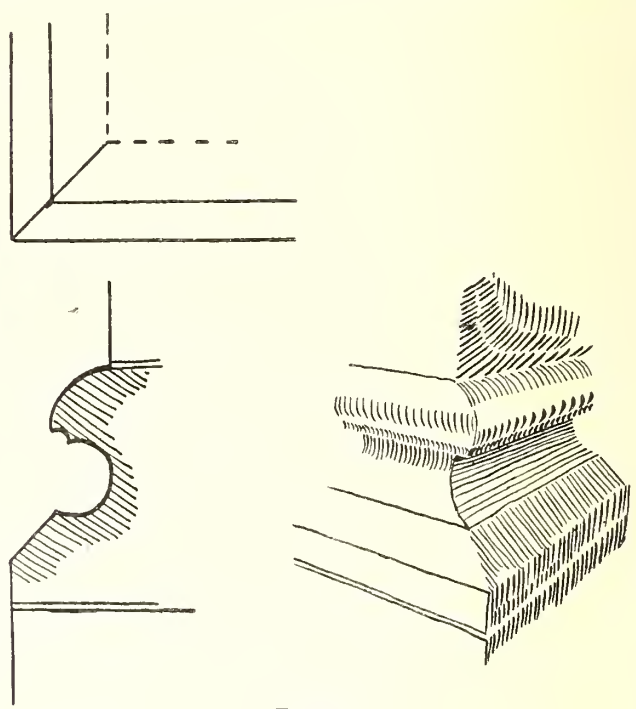


FIG. 224.

For angle stones the material is worked square to the extreme length, and the splay or mould worked back

on the two faces and at right angles, to form the mitre (see sketch, Fig. 224). In moulded plinths the same method applies, except as regards the template, which is cut to the form desired.

Strings are treated much in the same way. The rough faces are first splayed off to the rake of the moulding, and the finished mould droved and rubbed to the template. Copings require, in addition to the above, a special bevel cut to the rake or weather desired. These bevels are cut to the angle desired from the horizontal plane, drafts being run at each end of the stone, and the rake checked by the straight edge. The intervening rough stuff is knocked off and the whole brought down to the rake, forming a plane surface on the line of the drafts first sunk.

In all cases of copings, sills, and salient stones a groove or throating should be worked where convenient, on the under and projecting part, to throw off the water and prevent its entry into the adjacent joint. In many examples of mediæval work the copings have an embattled outline, formed by breaking the continuous line of the coping and sinking the intermediate stones to a lower plane. This serves to break up a long line of coping, which might otherwise give a sense of monotony.

In corbels, springers, kneelers, and apex stones the beds should be horizontal in the main wall; but where they abut on and form part of the coping, as in gables,

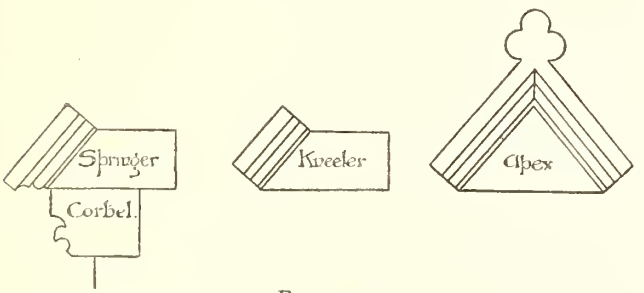


Fig. 225.

that portion of the stone which oversails and is coincident with the coping should have its beds or joints at right angles with the rake of the gable (see Fig. 225).

In cornices the stones should be carried through the entire thickness of the wall, especially where salient stones project to any great extent. Means of tying them down to ensure stability should also be employed, such as metal cramps run in with lead, interties, copper or gun-metal bolts, and other devices, and the stones joggled one to the other (see Fig. 226).

Sills are composed of one or more stones forming the base of a window opening, frequently projecting beyond the general face of the wall, and weathered, —that is, sloped outwards to throw off wet. In other words, the weathering should be brought to a lower surface than the plane of the square block out of which the sill is worked, leaving a narrow tabling as a seat for the wood sill of the window. This tabling should have a groove for the reception of a galvanised iron tongue. Where mullions are employed a seating is left square with the tabling before described, and the section of the mullion worked down to meet the weathering. The same applies to the junctions of the sills with the quoins, and the sides of the openings forming the jambs.

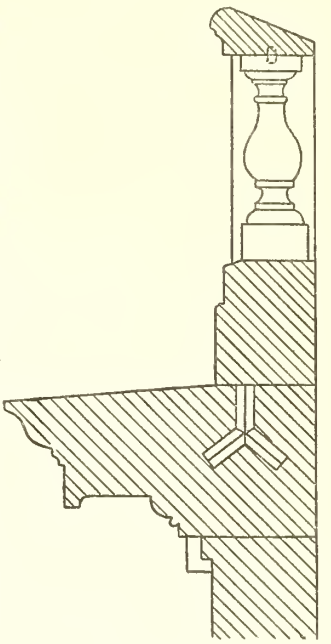


Fig. 226.

Heads, or lintels, are heavy stones bridging the opening over doors, windows, entrances, etc., and serving to transfer the superincumbent weight of the wall to the jambs. They are usually squared and finished with a splay, chamfer, or moulding, as the case may be, with mitred returns worked to the mould and within the stone. Cut templates have to be employed with the mould worked on in reverse, as it cannot be scribed at the ends and carried through as in string or plinth mouldings.

Lintels are sometimes cut with a curved, segmental, or other soffit, or with segments of arches inscribed

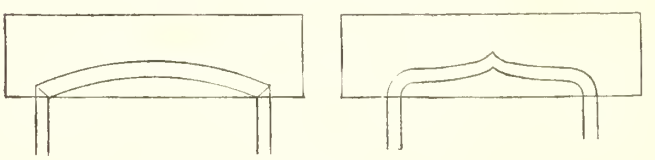


Fig. 227.

within the face, ogees, or other ornamentation (see Fig. 227).

There are many forms that can be applied to the flat lintel, but the above will suffice as examples.

Joints.—There are various methods of connecting stones together in addition to the adhesion provided by the use of mortar and cement. These are designed with a view to prevent shifting, or to provide stability where strain is anticipated; or else to form an additional protection from the entrance of rain water.

Where stones are bedded together and no particular strain is anticipated (it being presumed that it is not convenient to use one scantling) a plain vertical joint with two V slots from head to base is made, the opening thus left being filled with cement and pebbles, or with a slate dowel run in with cement.

For raking walls, such as towers, spires, etc., joints are sometimes fashioned in the form of a rebate (see A, Fig. 228), the joint being horizontal. Another form,

known as tabling (shown at B), is sometimes employed, but it is more expensive, as it involves considerably more work, and there may also be liability to the

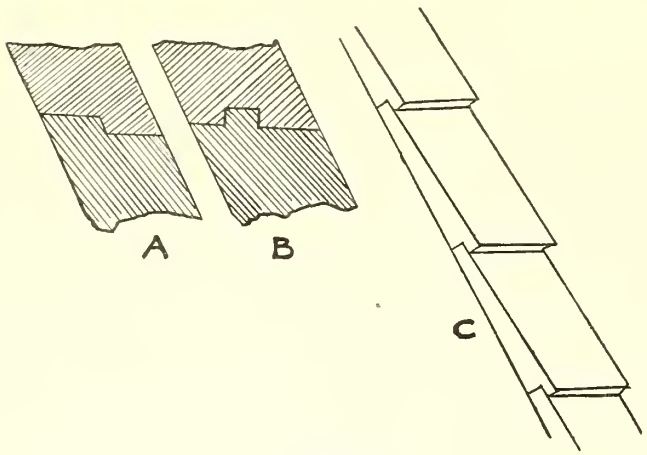


Fig. 228.

splitting off of the projection should undue strain be thrust upon it.

In gables a rebate is sometimes formed at the joints of the raking stones to keep the water out, as at C. It is a good joint, and serves its purpose well, but is expensive.

For the seats of sills, where the mullions or jamb stones rest, it is customary to insert a dowel about 1 inch square, usually of slate run in with cement. This effectually prevents sliding. Dowels are also used to connect thresholds with the stone immediately above in the same manner, and iron or slate dowels are inserted in thresholds, with 1 or 2-inch projections, to secure the wood frames of doors.

Where the bases of heavy iron columns or girders rest on stone templates, lewis bolts are inserted, being sunk from 4 to 6 inches in a dovetailed opening in the stone. The lewis is dropped in, and lead is run in to secure it.

Joggle joints are used to a great extent in landings, etc., where the widths are too great to admit of the convenient use of one single stone slab. The joint is formed as shown at A in Fig. 229, the joggle being cut to slightly taper, and run in with cement. Sometimes a longitudinal slate dowel is inserted, as at B, run in with cement as before. This is not so effectual as the joggle. A rebated joint is also sometimes employed, as at C.

Joggle joints are occasionally used in lintels, the projecting portion being rounded off and engaging with a groove of contrary section and equal size in the adjacent stone, as at D.

Secret joints are sometimes employed in Classic architecture for portière, entablatures, and lintels. Outwardly the joint is vertical, but the centre of the stone is cut in the form of a flattened wedge, with a corresponding cavity in the adjacent stone into which it engages, as at E. It is a good joint where no very severe strain is anticipated, and when metal cramps are undesirable. These are often used in gables, copings,

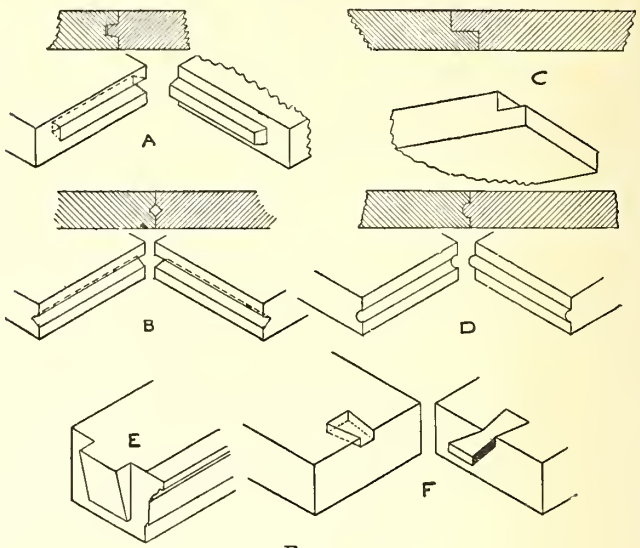


Fig. 229.

entablatures, etc., and are generally of copper, galvanised iron, or gun-metal. Slate cramps cut to a double dovetail are cheaper and very effective (see F, Fig. 229).

A very elaborate form of jointing was used in the construction of the Eddystone lighthouse, of such a nature that the structure partakes more of the nature of one solid stone than a collection of small parts. The joints were formed of a combination of rebates and dovetails

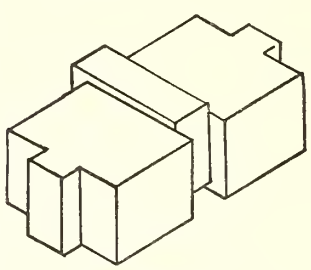


Fig. 230.

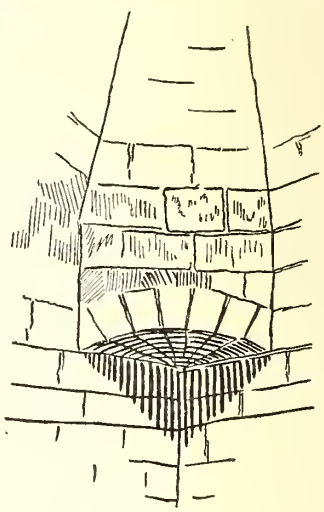


Fig. 231.

ingeniously formed to engage with one another not only horizontally but vertically. The work was carefully tested and the complete sets of each course laid out, fitted and numbered before being sent out to the site. A sketch of one of the stones will be sufficient to illustrate the general principles guiding the design of the structure (see Fig. 230).

In spires and domes a frequent method of counteracting the thrust of the superincumbent weight is that

of cutting a deep groove in the base or adjacent course, and inserting one or more stout chains or steel bands carefully run in with lead. Stonework in spires and domes should gradually diminish in thickness as the courses near the apex. In square towers with spires the angles are frequently spanned with squinch arches. These serve to throw the thrust at the angles more towards the main surface of the walls (see Fig. 231).

CHAPTER XIII

SCAFFOLDS AND GANTRIES

Scaffolds are of two general descriptions, namely—1. Bricklayers' Scaffolds. 2. Masons' Scaffolds.

1. The Bricklayers' Scaffold consists of five major members, namely—Standards, Ledgers, Putlogs, Scaffold Boards, and Braces.

Standards are upright members—usually fir poles of an average diameter of about 5 inches, and varying from 10 to 30 feet in length. These standards are arranged in a row about 4 feet 6 inches from the face of the work, and at distances apart of about 8 to 12 feet. The lower ends of the standards are usually buried in the ground to a depth of about 2 feet, the flags being lifted to enable this to be done when the scaffold is to be erected over a flagged path, as shown at B, Fig. 232. When it is undesirable to disturb the pavement the standards are usually placed in tubs and filled round with earth and well rammed, as shown at C, the tubs being placed, if possible, at the centres of flags, so that the pressure of the standard will be well distributed. When the scaffold is high the standards are built up of two or more poles lashed together, the lashings being tightened by wooden wedges; and if the height exceeds the first set of poles, other lengths of pole are added as the work proceeds.

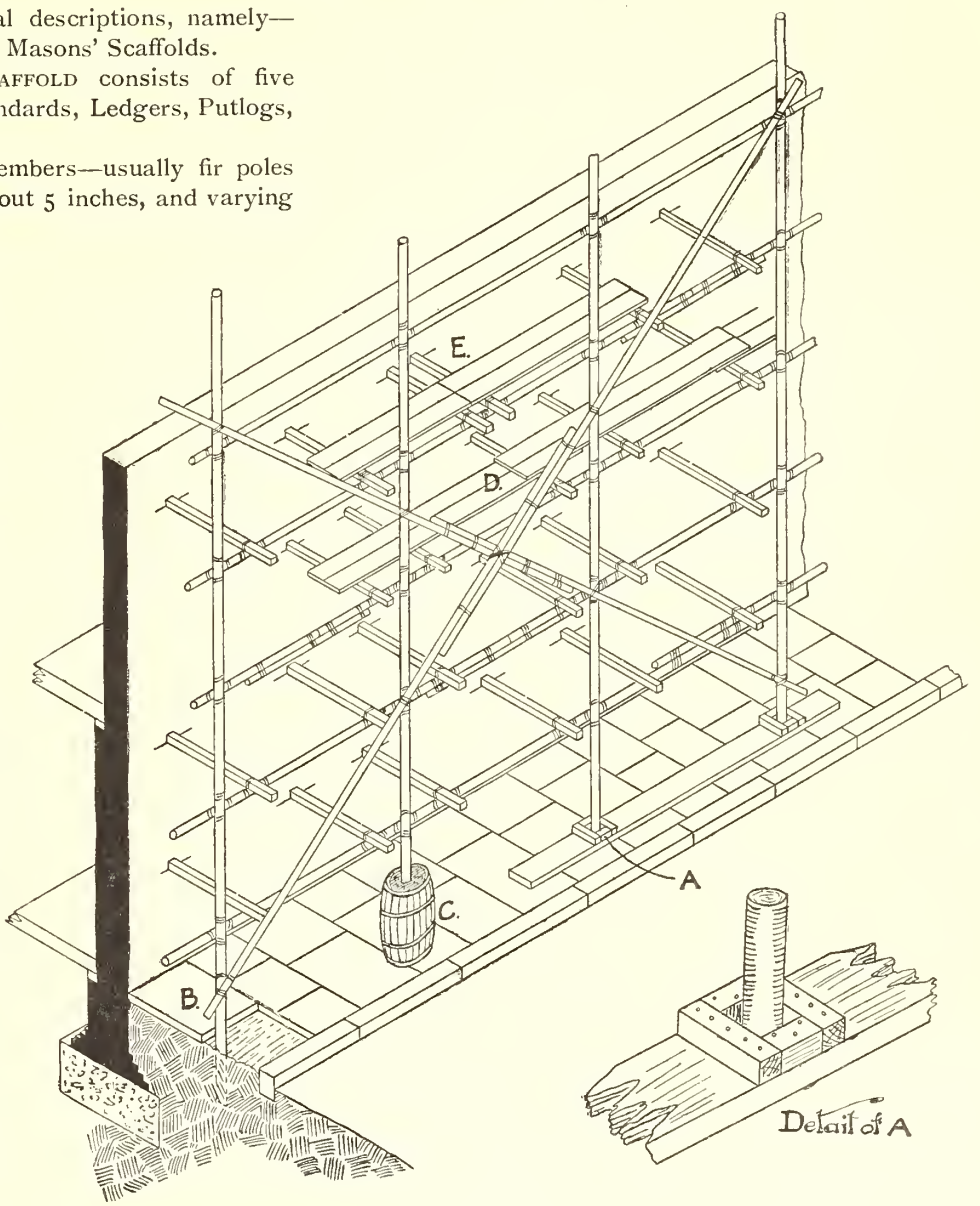


Fig. 232.

Ledgers, or *Runners*, are poles similar to those used for standards, and are fixed horizontally to the wall side of the standards by means of rope lashings tightened with wooden wedges. They are used to support one end of the putlogs, which in turn support the stages. It has been found that 5 feet is the greatest height at which a man can conveniently work, for which reason the ledgers are never spaced farther than 5 feet apart. Ledgers are lengthened by overlapping the ends and lashing them together and tightening by means of wedges, as shown in Fig. 232. The cords used for lashing are usually 8-feet lengths of hemp rope, three-quarter inches in diameter, bound at the ends to prevent fraying.

Putlogs are short lengths of birch split to a section of about 3 inches square, and cut to a length of from 5 to 6 feet. One end rests upon the wall while the other is supported by the ledger, to which it should be lashed for safety. These putlogs are spaced at intervals of from 4 to 5 feet. When the mortar of the brickwork round the ends of the putlogs has set, wedges are inserted round these ends to give greater security to the scaffold.

The Scaffold Boards, or *Sheetings*, are made from 8 to 12 feet long of 9 by 1½ inches spruce, with the ends bound in iron to prevent them from splitting, and are laid close together upon the putlogs to form a stage for the bricklayers to stand upon. The ends of the scaffold boards are either overlapped upon one putlog, as shown at D, Fig. 232, or butted against one another over two putlogs fixed about 4 inches apart, as shown at E. Both these methods prevent the board from tipping up when walked upon, and thus prevents accidents. The stages are made much firmer by nailing battens across the under sides of the scaffold boards, thus preventing them from sagging independently.

Other boards are placed with one edge resting upon the stages, and nailed against the standards to prevent pieces of material from falling off. These are called *Guard Boards*.

Wooden rails, called *Guard Rails*, are also sometimes fixed against the standards, to minimise the chance of workmen falling from the stages.

Poles, called *Braces*, similar to those used for standards and ledgers, are placed diagonally across, and lashed and wedged to the outsides of the standards, as shown in Fig. 232, to stiffen the scaffold.

Scaffolds for Repairing Purposes are easily erected against existing walls in the following manner: A stout timber is laid at about 4 feet from the wall, and 1½-inch fillets are raised to this, as shown at A, Fig. 232. The lower ends of the standards are placed in the troughs formed by these fillets, and the upper ends are rested against the wall, the lowest ledger being lashed to the standards. Headers are taken out from the walls just above the level of this ledger, and the ends of putlogs are wedged into the holes thus made. The standards are then pulled into vertical position by means of ropes, being prevented from falling by ropes taken through windows or from the roof tops, and the other ends of putlogs are lashed to the ledger. More putlogs are now inserted into holes cut into the wall, and lashed to the ledger to make it secure, and then the erection continues in the usual manner.

2. The Masons' Scaffold is built in a similar manner to the bricklayers' scaffold, but on account of the larger loads it usually has to carry it is made very much stronger, the standards being also closer together, while the whole is more heavily braced. As it is impossible to make holes in stone walls the putlogs have to be carried upon a second row of ledgers and standards, placed as near as possible to the wall without coming in the way of projecting cornices. The outer row of standards is placed about 4 feet away from the inner row. It is advisable, especially when the soil is soft, to rest the lower ends of the standards upon *Sleepers* or large *Sole pieces* to prevent them from sinking.

The putlogs are placed close spaced, and the stages are double boarded.

Sometimes scaffolds are erected on both sides of a wall. This is a good practice where a high class of work is required, but it is more economical to work the backs of walls from stages supported upon stout trestles carried on the floors. When scaffolds are erected on both sides of a wall they should be braced transversely through window openings.

Scaffolds are sometimes erected on the insides of walls only, but this is a bad practice, as it is difficult to finish the outsides neatly, or to properly inspect the work.

Communication to Scaffolds.—It is best and safest to place the ladder communicating with the stages within the thickness of the scaffold, the upper stages being reached by a series of fairly short ladders. Long climbs are very fatiguing to the hodmen who carry the bricks and mortar to the workmen on the stages. If long ladders are used, however, they should be strutted from the standards or from the ledgers to prevent them from swaying. All ladders should be securely lashed to the scaffold. On large building works it is most economical in labour to erect temporary wood stairs to enable the workmen to get at their work rapidly.

Gantries.—In towns where the lower portion of a scaffold would be likely to interfere with the traffic, timber structures not less than 10 feet high, called *Gantries*, are erected, usually spanning the footpath upon which the scaffolding rests.

These gantries are built up in the following manner: Two timber sleepers, varying from 6 by 6 inches to 12 by 12 inches, are laid on either side of the path, and uprights of the same size as the sleepers are placed upon and fixed to them with dogs. Heads or transoms of the same scantling as the uprights are laid across these uprights and dogged to them (see Fig. 233). Joints in the heads are arranged to come centrally over the uprights,

and a piece of timber is placed between the uprights and the head in order to increase the bearing of the latter.

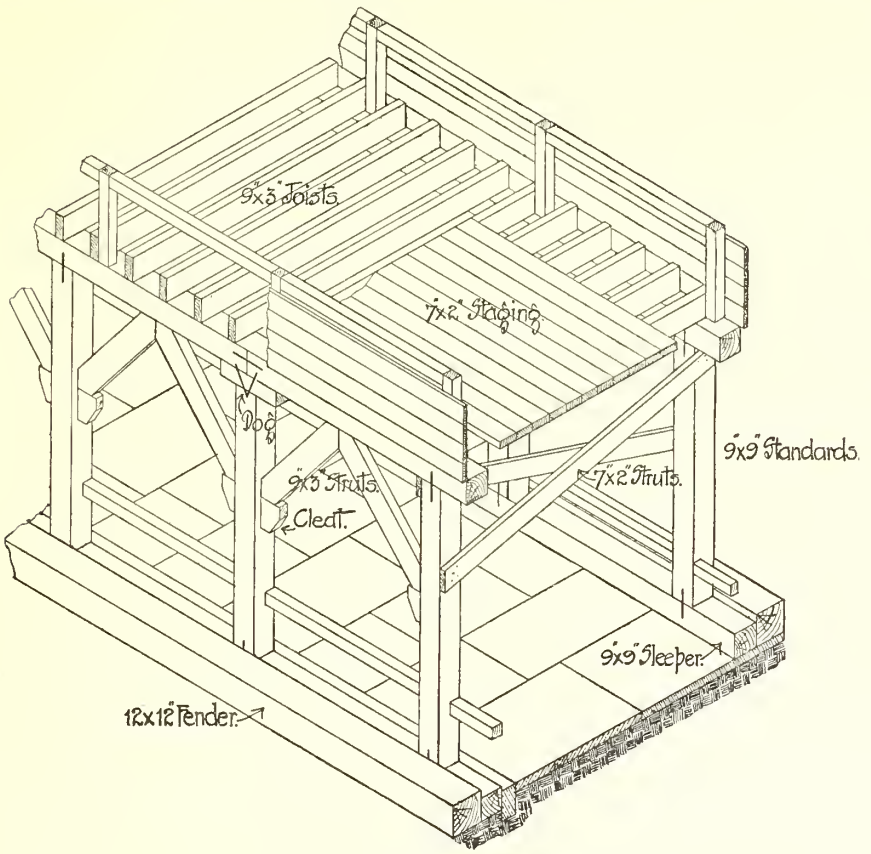


FIG. 233.

The heads are strutted between the uprights by means of struts inclined to about 45 degrees, and varying from 4 by 4 to 6 by 6 inches, supported at the lower ends by cleats, and butted against one another at the upper ends; or, if the uprights be too far apart to permit these ends to be butted, a straining piece is introduced between them and spiked to the head. The uprights are also braced transversely by rows of 7 by 2-inch timbers spiked diagonally between them. The lower ends of the struts and braces should not be lower than 6 feet 6 inches, otherwise they may prove a nuisance to people passing beneath the gantry.

The stage is formed by placing transverse beams, from 7 by 2 inches to 9 by 2 inches, upon the heads, and by spiking 9 by 3-inch boards, laid flat, upon these beams.

Rails and guard boards are usually placed round the edges of the stages, for the reasons already explained.

If the stages are large, quantities of materials may be stored upon them, or masons' or other sheds may be erected upon them.

Large balks of timber, with the ends splayed, and called *Fenders*, are fixed against the outside sleeper to prevent vehicles from coming in contact with the uprights. Sometimes the sleepers are connected together by means of transverse timbers halved to them, in which case a floor must be constructed by laying 7 by 2-inch to 9 by 3-inch boards on top of the transverse timbers, these boards being sloped up from the pavement at each end of the gantry, fillets of wood being nailed across them to give a good foothold. Gantries are often erected for the transport of materials, and of this class of gantry there are three types, namely—1. Fixed Gantries with Traveller. 2. Travelling Gantries. 3. Tower Gantries.

1. *Fixed Gantries with Travellers* are framed similarly to the stages shown in Fig. 233, save that they cannot be braced transversely except at the ends. Each upright is prevented from swinging transversely by strutting, as shown in Fig. 234. On top of the heads iron rails are fixed as shown, upon which a travelling beam which carries a travelling hoisting machine is placed.

The rails are turned up at the ends to prevent the traveller from running off, and guards are fixed at the ends of the beam to keep the crab on.

2. *Travelling Gantries.* — In this type of gantry the whole framework runs along rails supported upon sleepers, and consists of two strong trestles spanned by a trussed cross beam upon which the crab rests. The usual method of framing these gantries is shown in Fig. 235.

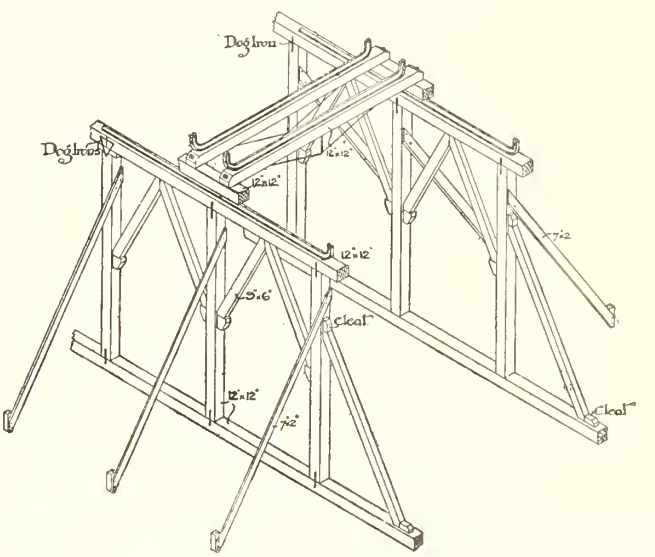


FIG. 234.

3. *Tower Gantries*, or *Derrick Towers*, are lofty stages, supported upon three or four "*towers*," or legs built up

of timber. Upon those platforms derrick cranes are supported for the transport of material to various parts of the building. The towers, which are about 6 feet square, are disposed on plan in the form of an isosceles triangle, and are paced from 20 to 30 feet apart, and rest upon platforms formed of layers of 9 by 3-inch deals, well spiked together, and varying in size according to the nature of the soil upon which they rest. Uprights, usually built up of three layers of 9 by 3-inch deals of varying lengths bolted together, are placed at the

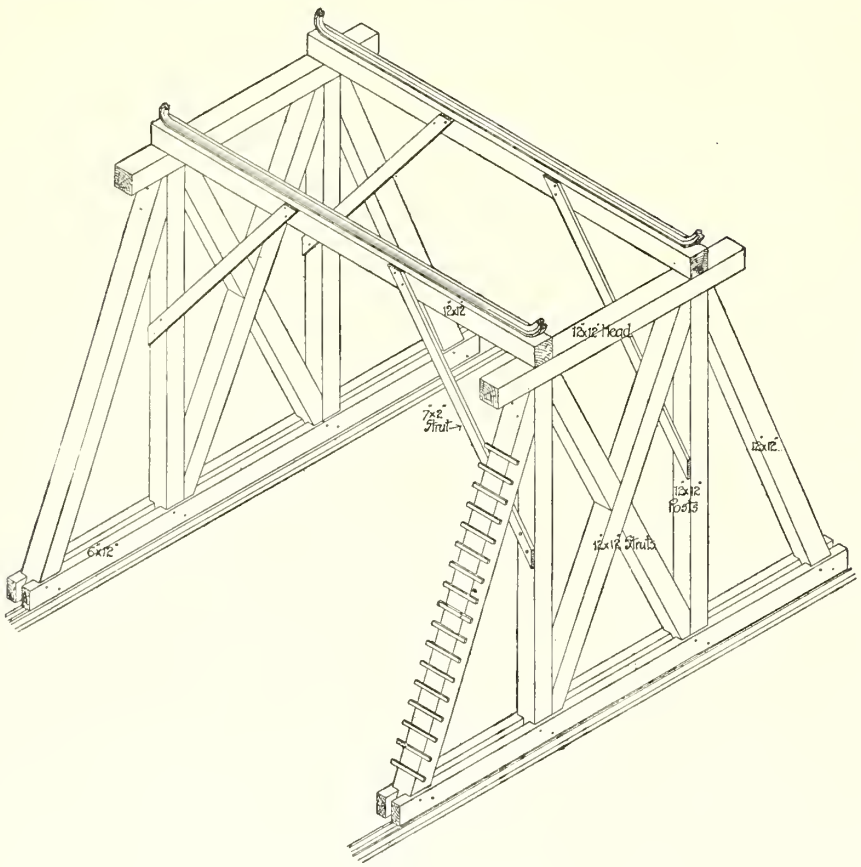


Fig. 235.

corners of the towers and connected at intervals of from 10 to 12 feet by means of 9 by 3-inch cross struts or transoms securely bolted to the uprights. Diagonal struts, cut out of 9 by 3-inch deals, are then securely bolted between the transoms, as shown in Fig. 235A. The towers are carried up in a series of trussed bays until the desired height is reached. Trussed beams are built across from the tower, forming the apex of the isosceles triangle on plan to the other towers, these beams being built up as follows: Solid timbers, usually 12 by 12 inches, form the upper and lower booms, which are supported upon the two uppermost transoms, which are spaced from 5 to 6 feet apart vertically. The upper booms are halved at their intersection, carried on to project about 4 feet beyond the tower, and strutted from one of the transoms. These two booms are connected together by means of iron bolts spaced about 6 feet apart. Wooden uprights and cross bracing, cut out of 6 by 6-inch timber, is fitted between the booms, and securely fixed by screwing up the nut ends of the bolts. A 12 by 12-inch timber is thrown across the remaining side, resting upon the top transoms of the towers, and stiffened by means of struts supported at their lower ends upon one of the transoms of the towers, and butting at the upper ends against a straining piece spiked to the beam.

Joists are laid across these beams to support the stage. The crane is placed over the leg upon which the trussed beams meet, and this leg is sometimes furnished with a stout central standard strutted at intervals from the transoms. The crane consists of an upright member called a *Mast*, fixed at the lower end to a pivoted base and pivoted at the top to the ends of two *Stays*, which are fixed at their lower ends to *Sleepers*. These sleepers lie on the staging, and are connected to the base of the mast by a pivoted joint. A member called a *Jib* is connected by means of a hinged joint to the lower end of the mast, while the upper end is slung by a chain passing over a pulley at the top of the mast to a steam winch, thus enabling the jib to be raised or lowered in a vertical plane. A steel rope or chain for supporting the loads is passed over pulleys, one at the upper end of the jib and one at the upper end of the mast, and is then carried round the drum of a steam winch for raising or lowering the loads.

Stout chains are fixed to the sleepers beneath the lower ends of the stays, and securely fixed to the platform at the bottom of the supporting towers. These are weighed down with bricks, stones, or other suitable material. Care should be taken to keep these chains tight, otherwise they will tighten up with a jerk every time a load is lifted by the crane. For this reason a screw coupling link is inserted in the chains, which should be inspected every day and tightened if necessary.

The load at the bottom of towers is sometimes supported on platforms resting upon the lowest transoms to make the towers as stable as possible. The load at bottom of the towers beneath the stays should always be at least twice the heaviest load likely to be supported from the jib.

Before setting up a tower gantry over a site the plans of the proposed building should be consulted and the position which will give the maximum range to the crane determined.

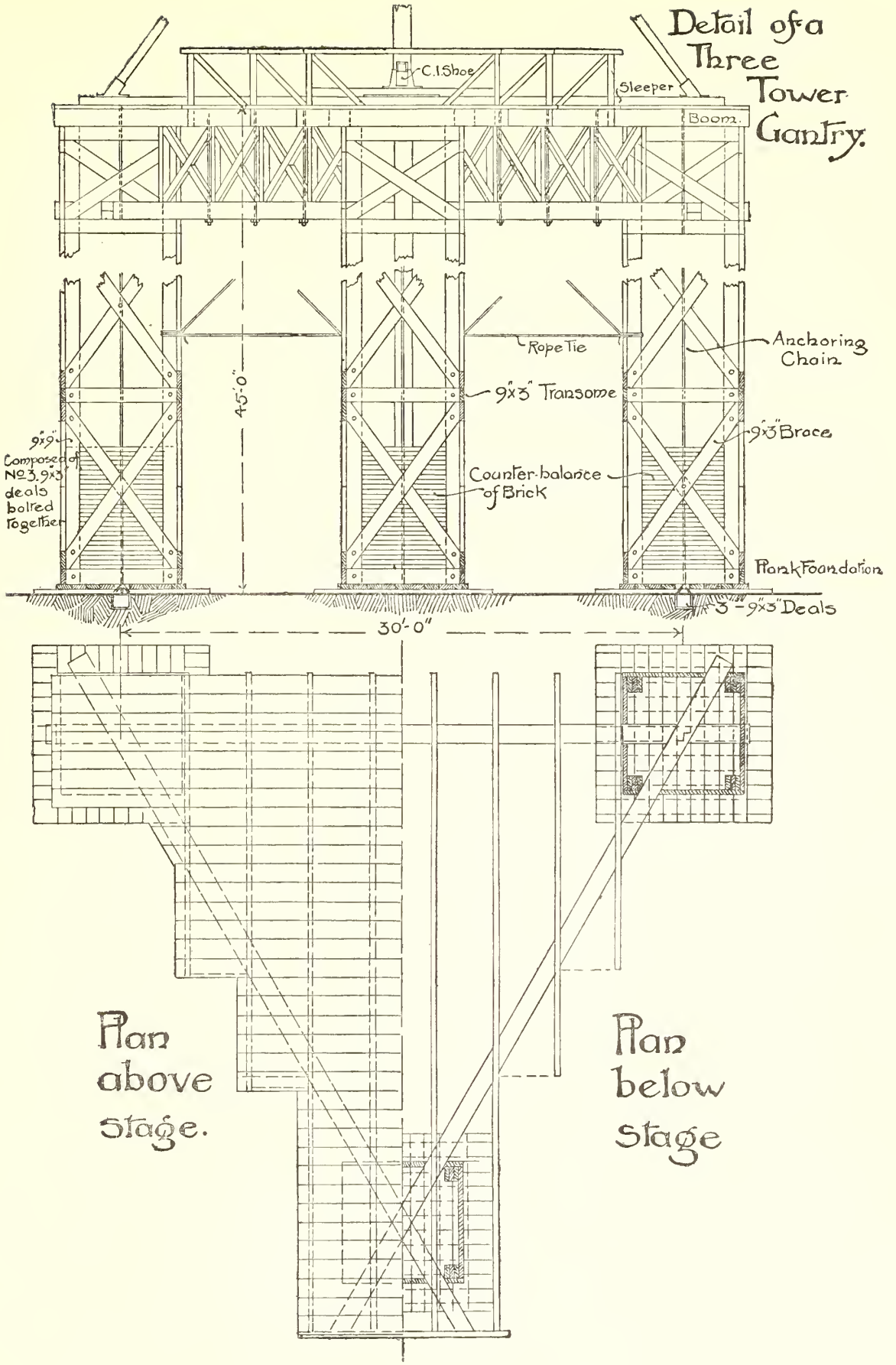

Detail of a Three Tower Gantry.
C.I. Shoe
Sleeper
Boom.
Rope Tie
Anchoring Chain
9"x3" Transome
45'-0"
9"x3" Brace
9"x9" Composed of No 3. 9"x3" deals bolted together
Counter-balance of Brick
Plank Foundation
3 - 9"x3" Deals
30'-0"
Plan above stage.
Plan below stage

FIG. 235A

CHAPTER XIV

TURNING PIECES—CENTRES AND CENTERING

In constructing arches the voussoirs are headed one upon another, commencing with the springers and building up towards the crown on either side, until the arch is finally completed by the insertion of the keystone. As the crown of the arch is approached the bed joints of the voussoirs become less obliquely inclined to the horizon, or, in other words, become more nearly vertical, while the tendency of the voussoirs to slide upon one another gradually increases. It becomes necessary, therefore, to support them until the arch is completed, the nature of the support depending upon the size of the arch and the weight of the voussoirs.

Turning Pieces.—When small arches of only a few inches rise are to be constructed the voussoirs are supported during the course of construction upon solid

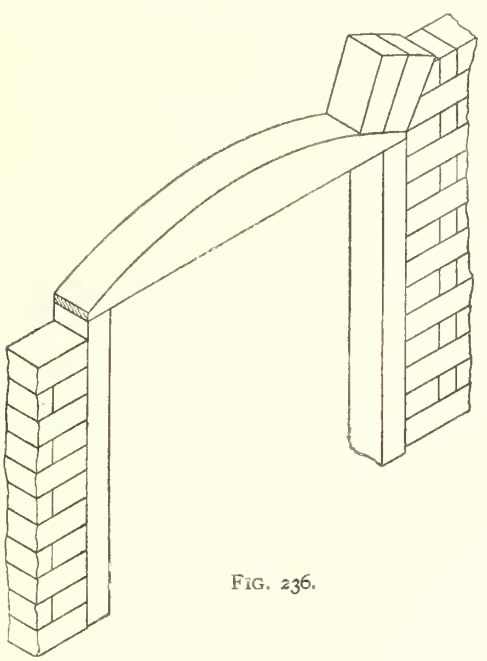


Fig. 236.

pieces of timber, with the upper surface cut to the curve of the intrados of the arch, as shown in Fig. 236.

Centres.—When arches of considerable span and rise have to be constructed the voussoirs are supported during the course of construction upon frameworks of timber called *Centres*. These centres vary considerably in their construction, according to size of the arch and the magnitude of the loads to be borne.

Centres may be classified as—

1. Centres with Solid Ribs.
2. Centres with Built-up Ribs.

1. Centres with Solid Ribs are used for small arches. They are composed of two ribs of 1-inch boards with the upper edges cut to a curve. The lower corners of the ribs are nailed to *Stretchers*, also out of 1-inch boards ; the length of these is a little less than the thickness of the wall in which the arch occurs. To the upper edges of the ribs $1\frac{1}{2}$ by $\frac{3}{4}$-inch *Lagging Pieces* are nailed, as shown in Fig. 237. The centre thus formed is supported upon uprights, the lower ends of which rest upon the upper surface of the sill below, and a piece of wood slightly larger than the width of the opening is fixed between the uprights to keep them in position. Wedges are inserted between the head of the upright and the stretchers, which enable the centre to be eased when the arch is completed.

Centres with Built-up Ribs are of two kinds—

(*a*) Centres with Laminated Ribs.

(*b*) Centres with Ribs built up of Solid Timber.

Before designing a centre for any particular arch the principles upon which all centres are constructed should be understood.

During the construction of an arch ring the load increases as voussoirs are added on either side, and the increasing load creates varying stresses in the ribs of the centre. Thus when the arch ring has been built up to about half-way between the springing and the crown there is a tendency for the load to push in the lower portions of the ribs, and in doing so to raise the upper portions, while when the arch ring is complete the tendencies are reversed ; that is to say, the upper portions of the ribs tend to sag, while the lower portions tend to bulge outwards.

It is clear from the above facts that the ribs must be supported at intervals by means of braces which are not only capable of resisting these varying stresses, but must be so placed that the two tendencies to sag or rise counteract one another.

The centres, being of a temporary nature, should be so designed that their timbers may be cut or spoilt as little as possible, so that they may be used again for other purposes.

The joints should also be designed to resist the varying stresses, tenoned joints being useless for the purpose, save where the tenon is used to prevent lateral motion in the timbers.

(*a*) Centres with Laminated Ribs, as their name implies, have their ribs built up in sections, out of thin boards in two or more thicknesses, nailed together so as to breakjoint, as in Fig. 238. The length of the sections of the ribs is determined by the width

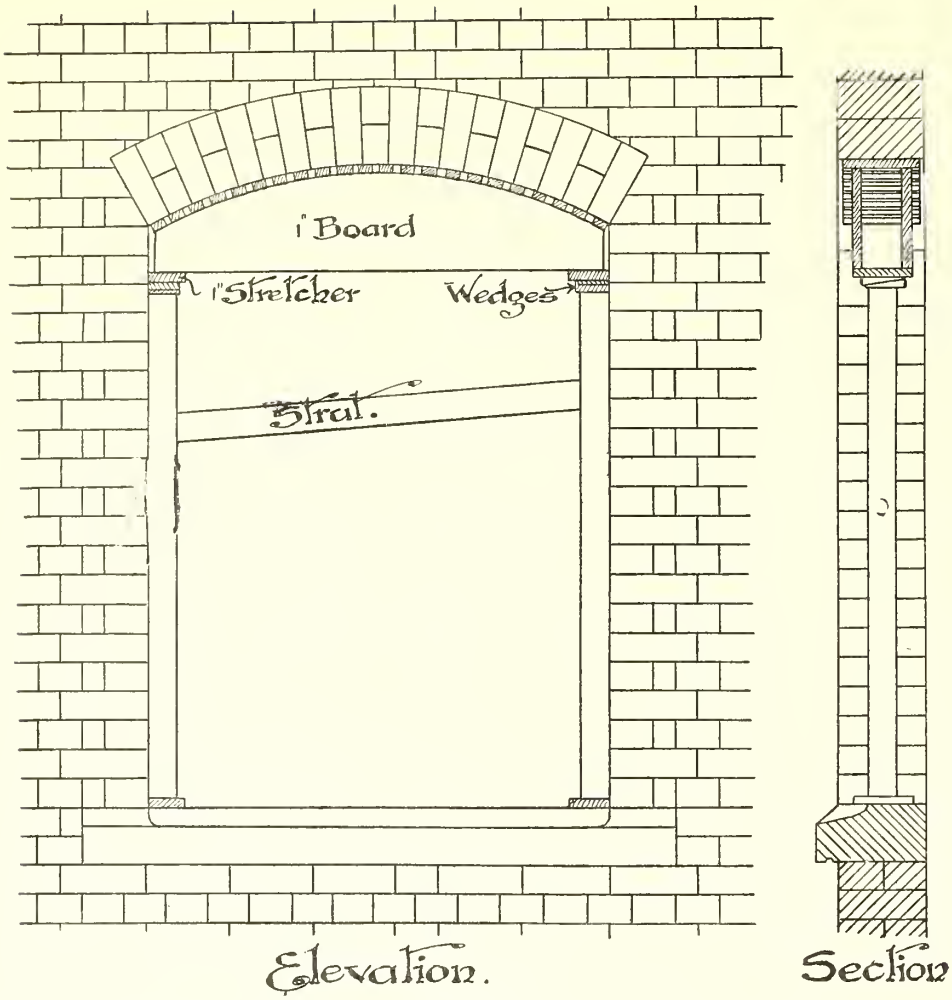


FIG. 237.

of the board from which they are cut, boards 9 by 1 inch being generally used; and the sections should never be so long as to cause their end to be less than 4½ inches wide. One of the lowest sections on each side of each rib is stopped short of the springing so as to form a rebate for a *Tie*, which varies from 6 by 1 inch to 9 by 2 inches, according to the span of the arch, this tie being nailed at each end to the rib. To prevent the haunches from sinking and the crown from rising, or *vice-versâ*, during the construction of the arch, the rib is strengthened by three braces, varying from 6 by 1 inch to 9 by 1 inch, according to the span. Each brace is cut at the upper end to fit into the angle formed by two sections of one lamination, and is nailed to the overlapping section of the other lamination, while the lower ends are securely nailed to the middle of the tie.

For a wall arch two such ribs are connected together by nailing two stretchers, one at either end of the ties. Lagging pieces are then nailed across the curved edges of the ribs. If the arch is to be rough, 2 by 1 inch lagging pieces are used, spaced openly as shown on the left-hand side of Fig. 238; but if the arch is in gauged brickwork the lagging pieces are placed close together, and their edges are trimmed with a plane to the desired curve, or else the lagging is formed of two thicknesses of 11 by ⅜-inch pine bent to the curve of the ribs. When a small arch is constructed of stone the voussoirs are supported by a single lagging piece occurring at each *joint*, as shown on the right-hand side of Fig. 238. This type of centre is used for spans of from 5 to 12 feet.

(*b*) CENTRES WITH RIBS BUILT UP OF SOLID TIMBER.—In this kind of centre the ribs are built up out of solid pieces of timber, the length of the sections being regulated, as in laminated ribs, by the width of the

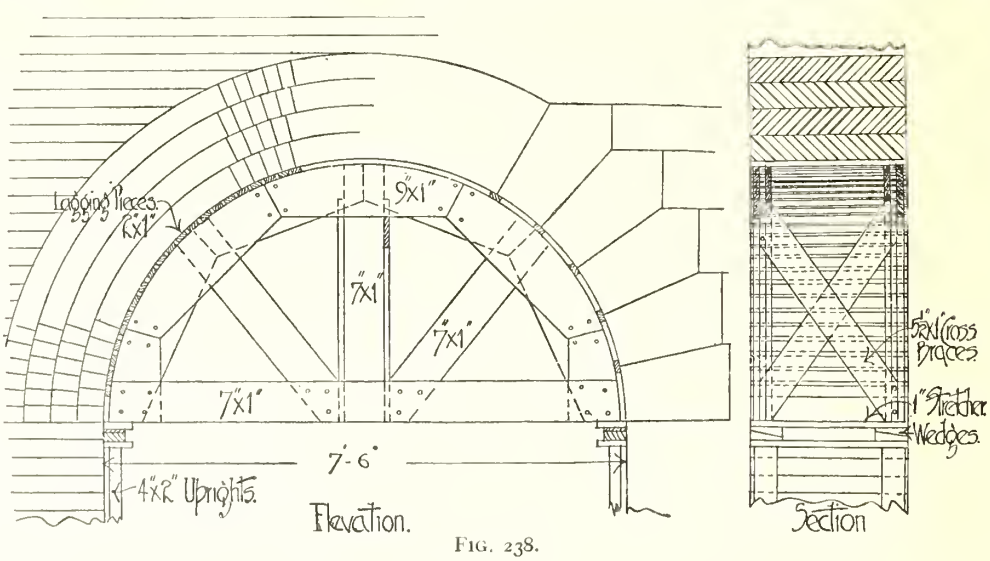


FIG. 238.

timber from which they are cut. When timbers are not at hand of sufficient width to enable sections of convenient length to be cut from them, the sections may be formed out of narrow timbers *firred up, i.e.*

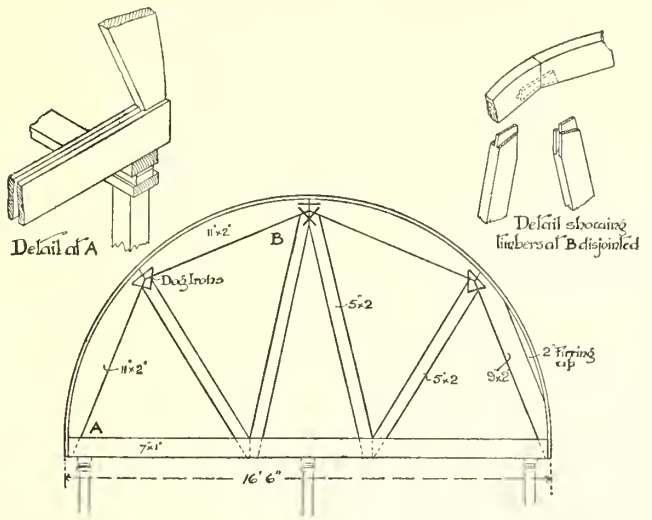


FIG. 239.

with pieces of timber cut to the required curve, spiked to the tops of them, as shown on the right-hand side of Fig. 239, which shows a good type of centre for arches with spans of from 12 to 20 feet. The ribs are built of 12 by 2-inch boards dogged together. The tie is formed in two 7 by 1-inch timbers, notched and bolted at the ends to the lower extremities of the ribs, as shown at A. The upper ends of the braces are tenoned into the rib at the junctions of the sections and secured by dogs, as shown at B, while the lower ends are fitted and bolted between the ties.

Fig. 240 shows a very stiff type of centre, suitable for arches up to 25 feet in span, in which the load from the haunches is carried to the foot of the central or king post by means of the struts SS, while the load on the crown is carried to the ends of the tie. Should the haunches tend to rise they are prevented from doing so by means of the braces T and U, while any tendency for the crown to lift is checked partly by the brace U and the corresponding member on the other side of the centre, and partly by the bolts securing it to the head of the king post.

Fig. 241 shows a type of centre which may be used for spans up to 40 feet, when the space beneath the arch is required while the building operation is in process. Here the load on the crown is carried directly to the supports, while the haunches are tied together and each joint supported by braces.

CONSTRUCTING THE CENTRES.—Having designed the centres, they should be completely set out, full size, in chalk lines upon a floor or other suitable level surface. The timbers from which the sections of the ribs are to be cut are laid over the chalk diagram, and the joints are marked upon them. They are then taken up and the joints are cut, and the sections fitted and dogged together over the diagram. The curved edge is now marked upon them with a radius rod. The sections are then taken up again and cut to the curve and once more fitted into position, being kept there by driving spikes into the floor against their edges. The timbers for forming the ties and braces are then laid down in position, and marked for the necessary shoulders, notches, and bolts. These are then cut, and the whole centre fitted together to see that every member fits properly. All the joints should then be marked with some distinguishing mark to facilitate the refixing in the required position.

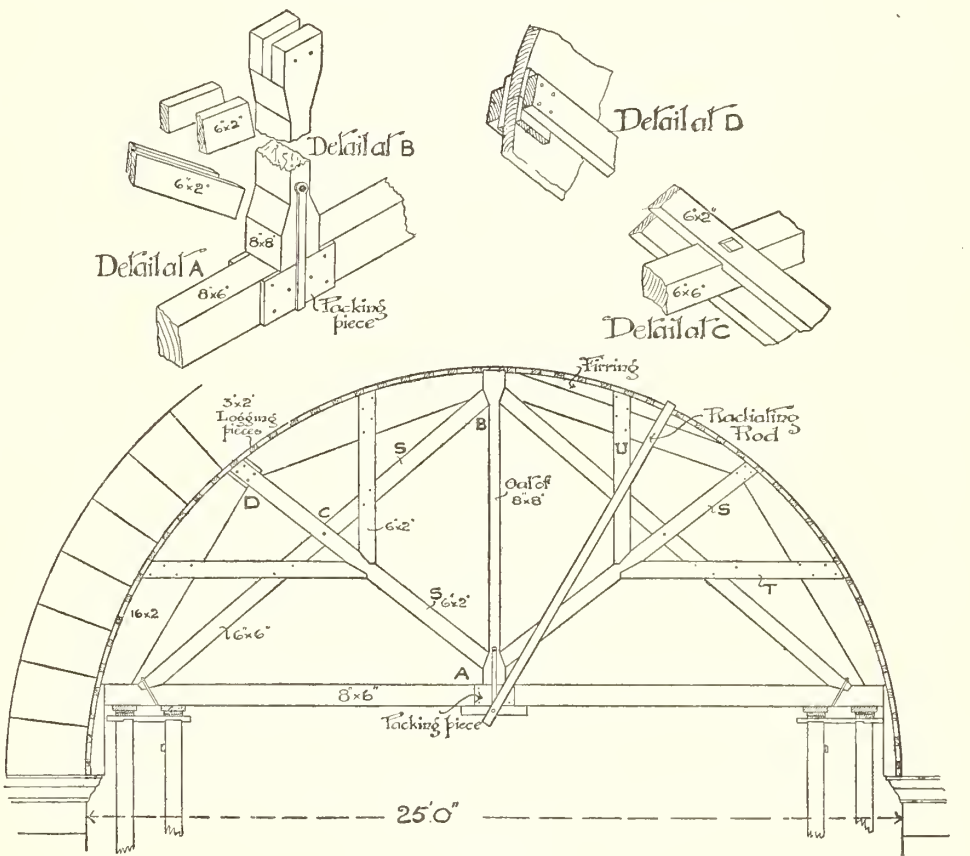


FIG. 240.

Setting up the Centres. — Small centres may be fixed together in the carpenter's shop, but large centres should always be built up *in situ*, as slinging the

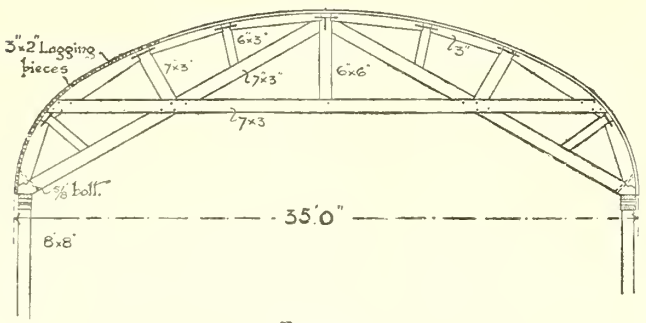


Fig. 241.

complete centres into position frequently strains the joints or distorts the curve of the ribs.

Supports for Centres.—Supports for centres should be placed immediately under those members which have most of the strain—that is to say, they should be placed at the ends of the ribs, and under the junction of the braces and tie.

Centres are usually supported on upright timbers varying from 4 by 2 inches to 12 by 12 inches, according to the size of the arch. The lower ends of these timbers rest upon sleepers so as to distribute the load, and are secured by means of dogs to prevent them from being knocked out of position. When the space under an arch is not required while the building operations are in progress, economy may usually be effected by supporting each rib at frequent intervals across the span by upright supports; but should the space be required the supports of the central portions of the centre should be inclined or a truss of the kind shown in Fig. 241 should be used. It is a bad plan, however, to use inclined supports, as they are apt to work loose, and thus cause the centre to sag.

When the arch is deep, as in a barrel vault or an arch carrying a road or footpath, the ribs should be placed at intervals of from 3 to 4 feet apart, being strutted transversely if necessary, and each rib being supported by uprights. Struts are placed between the uprights to stiffen them. A horizontal timber is secured to the head of each row of uprights, and above this a second horizontal timber is placed to support the ribs of the centre, wedges being inserted between these horizontal timbers to facilitate adjustment and easing on the completion of the arch.

When a series of arches has to be constructed the supports of the centres should be carried upon the footings of the abutments, otherwise there is a tendency for the abutments to settle unevenly when the centres are removed.

In setting up the centres of deep arches the two end ribs should be set up first, and most accurately adjusted by means of the wedges, and the curve tested by means of a radius rod. The intermediate ribs are then placed in position and adjusted to a straight edge laid across the end ribs. If the curve of the intermediate ribs be untrue it can be adjusted by notching the lagging pieces over them more or less, as the case may require.

Additional stiffness can be given to the centre by means of transverse braces.

Screw-jacks are sometimes used instead of wedges for easing the centres.

Easing the Centres.—When the arches are complete and the mortar set the centres should be eased gradually and evenly, so that the weight is not suddenly brought upon the abutments. The wedges should be planed and oiled or blackleaded, so that they slip easily, blocks being nailed against them to prevent them from slipping right out.

When large projecting mouldings occur at the springings the centre must be so designed so that the tie comes high enough to permit the centre to be eased and removed, the lower courses of the arch being supported upon tailing pieces, as in Fig. 240. These are rarely necessary in stone arches, as no weight is brought upon the centres until the angle of the bed joints of the voussoirs with the horizon exceeds that at which they would begin to slide—about 30 degrees, while with brick voussoirs the tail pieces form a mould for the soffit of the arch.

CHAPTER XV

SHORING, NEEDLING, AND UNDER-PINNING

(*By The Editor*)

Shores are temporary supports to walls and buildings, and are usually employed when these are in dangerous condition and likely to fall over. They are almost invariably constructed of timber, and are of two principal types, known as "Raking shores" and "Flying shores" respectively.

Raking Shores are such as rest upon the ground and support the wall or building by being inclined against it. A simple form is shown in Fig. 242. It consists of a "raker" A, resting upon a "sole piece" B, to which it is placed nearly at right angles, although not quite so, being levered into position by means of a crowbar; it is thus tightened up against the short "needle" C, which passes through the "wall piece" D, and a short distance into the wall. E, E are small "cleats" which are spiked to the sole piece and wall piece respectively to secure stability. The foot or bottom of the shore A is further secured to the sole piece by means of dog irons; while the strut F is commonly but not necessarily inserted to give rigidity to the system.

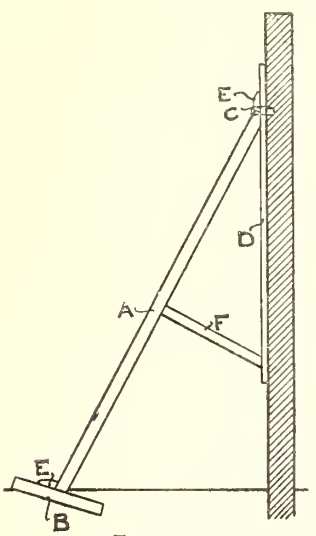


Fig. 242.

A more elaborate and more usual system of raking shore is that shown in Fig. 243, A, B, and C being known as the bottom, middle, and top rakers respectively. These are bound together with hoop iron at the foot, and are also connected both to one another and to the wall piece by planks. The sole piece in this instance is shown resting upon a platform of boards, this being necessary for all other than very solid ground in order to distribute the thrust.

Another and even more elaborate system is shown in Fig. 244, consisting of the previous system with what is known as a "Ride or Riding shore" springing from the back of the top raker. This system is employed for tall houses only, where a timber long enough for a fourth or outer raker is not obtainable in a single piece.

The method of attaching these various members to one another is shown in the details which comprise Fig. 245.

When erecting raking shores of either of these descriptions, care should be taken to place the tops of the rakers at the level of the various floors of the building, so that when levered into place they may resist any thrust from the floors, and not themselves exert an undue inward pressure upon unsupported wall, and so cause failure in the opposite direction to any bulge that there may be in the brickwork or masonry. Alternatively to this, the shores may be

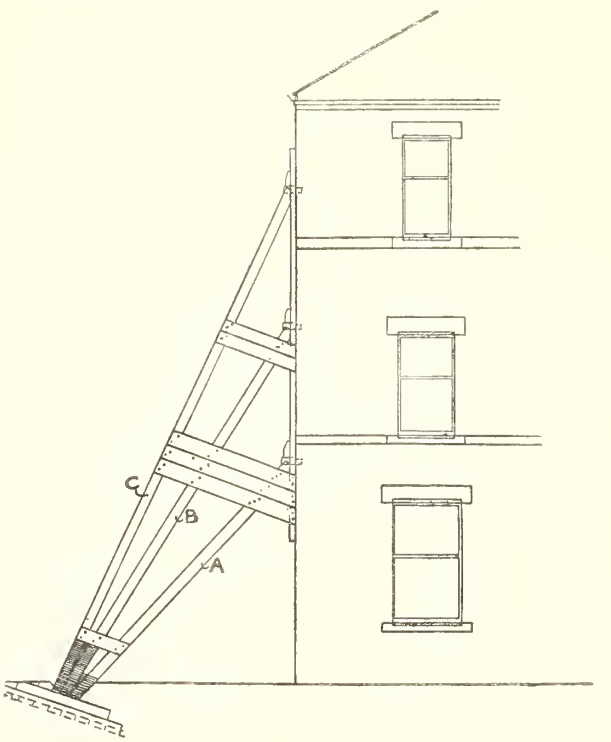


Fig. 243.

placed against the ends of internal walls. Frequently this is essential, it being these walls which are tending to cause failure; but no definite rules can be laid down, as shoring is at best a rough-and-ready means of meeting temporary difficulties. It is, for instance, impossible to calculate what sizes the timbers ought to be, as the thrusts to which they are to be exposed are almost always unascertainable. It may, however, be taken as a general rule that if the distance from the top needle to the sole piece in feet be divided by five this will give the size of the timber to be used in inches. Thus if the distance be 35 feet, the rakers should all consist of 7 by 7-inch timbers. Frequently,

however, shoring has to be done at short notice, and whatever timbers are available are used.

Sometimes for supporting garden or retaining walls of small size a small, strongly constructed double shore of the type shown in Fig. 246 is used. The heads of these are shown to be bearing upon the under side of stone slabs inserted in holes made in the wall; and this method of support is frequently employed instead of wall pieces, when using the ordinary raking snores against stone buildings.

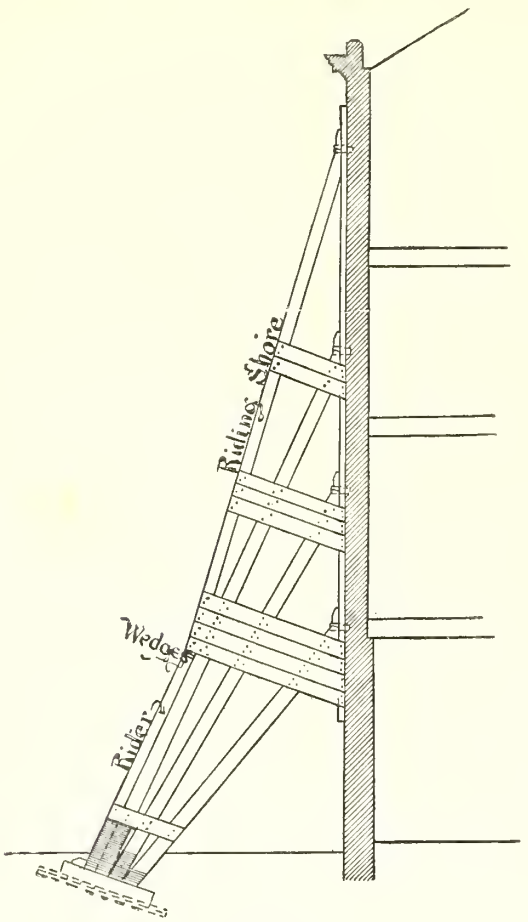


Fig. 244.

Flying Shores are such as are used to support one building from another across an intervening space; they are frequently employed during building operations, when one house of a row has been pulled down for rebuilding. The ordinary form is shown in Fig. 247, though it is varied occasionally by the use of steel joists in place of the long horizontal timber when this is not obtainable of sufficient length. This, it will be noticed, is supported upon a small needle and cleat, as are the heads of raking shores, but it is further pinned up tightly against the wall piece by means of oak wedges. Upon the upper and under sides of this, straining pieces are nailed from which struts spring upwards and downwards, and these are wedged up, from the straining piece, against other cleats spiked to the wall piece.

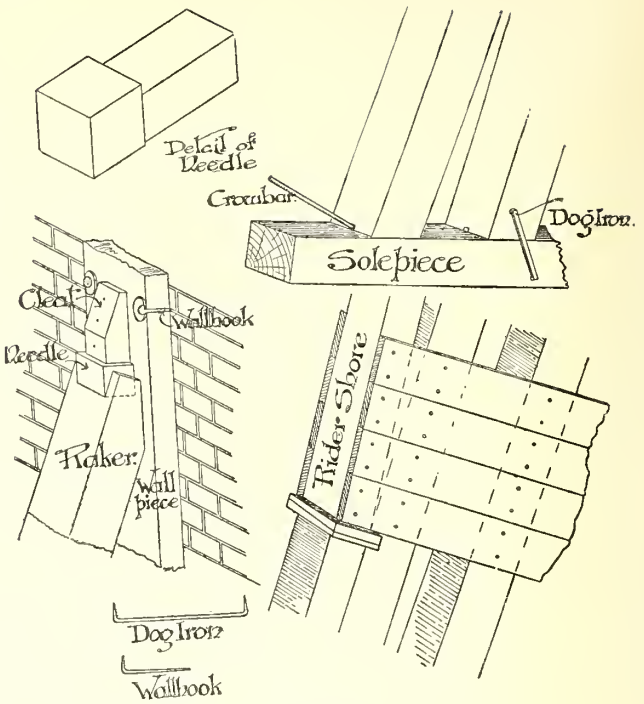


Fig. 245.

A variation of the Flying Shore is that shown in Fig. 248. This is usually employed for comparatively narrow spans, and for supporting a higher building from a lower one. It is open to considerable variation,

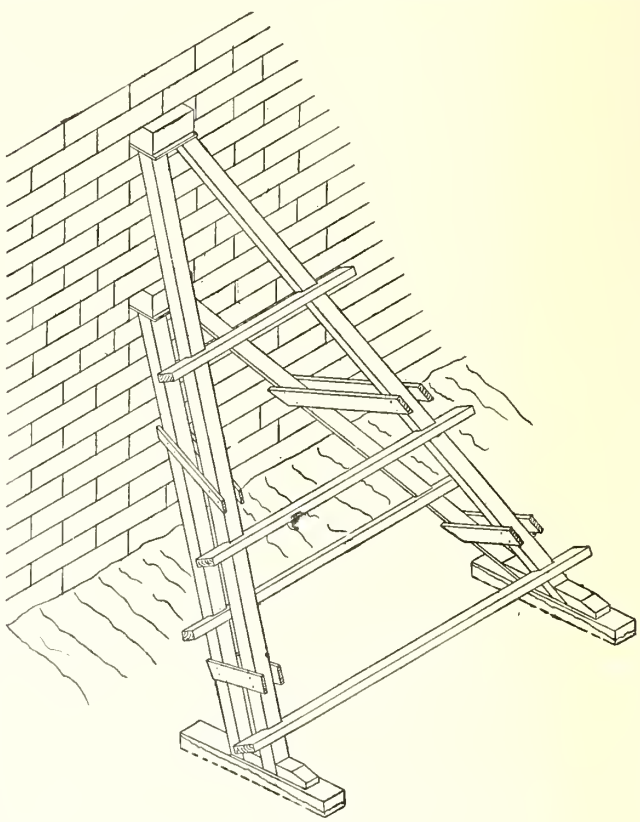


Fig. 246.

according to the circumstances of each individual case.

Needling.—When it is intended to remove the lower portion of a building, as, for example, for the insertion of a bay window or a shop front, the upper part has to be temporarily supported. This process is known as

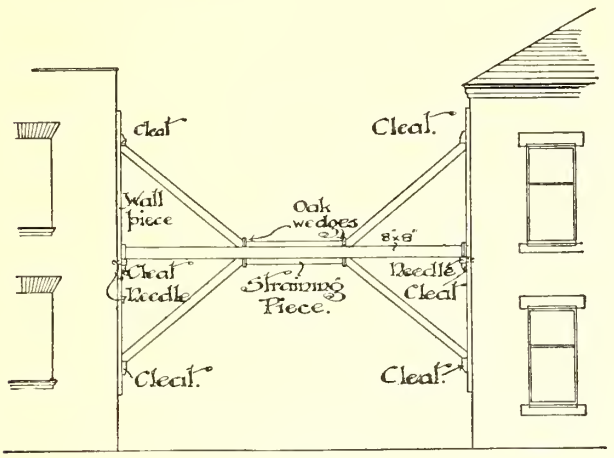


Fig. 247.

cross strutted, both internally and externally, the window frames being temporarily removed.

The operation of needling is by no means one to be lightly undertaken, and has to be done with the greatest care. Large timbers (see Fig. 249), either 12 by 21 inches or 9 by 9 inches, are commonly employed.

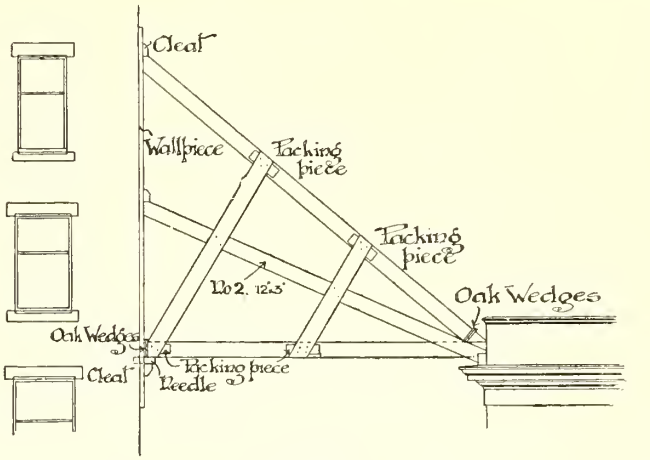


Fig. 248.

"Needling." Before this is done, however, it is usual and proper to take the precaution of erecting raking shores against the upper walls, so as to resist any tendency to bulge during the process, placing these at the corner of the building and opposite any cross walls. All windows over the projected opening should also be

A long sole piece of this size is first laid on solid ground parallel to the wall, both within and without the building. It is not sufficient, it may be noticed, for this to rest upon a floor. It must be carried on the solid, and, if the soil be at all doubtful, should rest upon a broad platform of planks. Upon this a series of

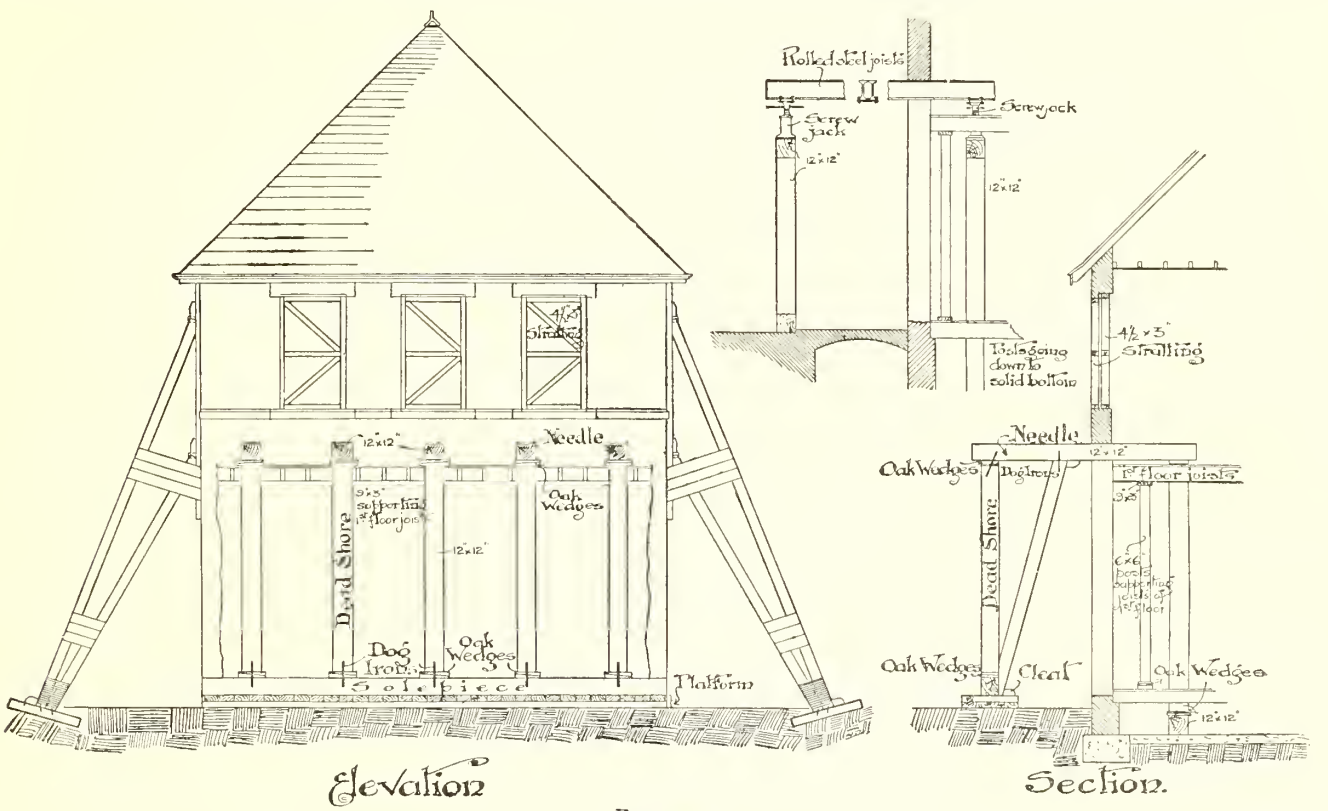


Fig. 249.

vertical timbers known as "Dead Shores" are erected with oak wedges underneath their bases, but all of equal height in each range — external or internal. All these must be opposite to one another on the internal and external sole pieces, and, directly in line between them and at the level of their heads, a hole is made in the wall through which a strong bearing timber known as a "Needle" is passed, so as to rest on the heads of the "Dead Shores," to which they are attached by dog irons. These needles are brought up tightly against the brickwork above by driving up the oak wedges. The dead shores are now dogged to the sole piece, and if for any reason they are more than some 2 feet from the wall a strut is inserted, as shown in the illustration. If any floor rests on the wall which is being dealt with, the joists are supported by a piece of timber running transversely underneath them, and about 2 feet from their bearing on the wall. This timber is carried at 5 or 6-feet intervals by posts, which in turn have their feet resting on another timber lying on a floor below or on the ground, wedges being driven in to make them firm. An alternative method is shown in Fig. 249, sometimes employed for extremely heavy work, the fir needles being replaced by steel joists or built-up girdles, which are brought up to their work by screw-jacks instead of wedges. These, however, must be used with some caution, as it is quite possible to screw them up too far.

Systems of needles thus constructed on the same internal and external sole pieces are placed not more than 5 feet apart, and when all have been wedged up, the brickwork or masonwork between them may be safely removed, as the wall above will now be carried by them even though there be no longitudinal bearer from one to another. As soon as possible, however, the piers should be made good, and built up in cement, and a girder inserted beneath the level of the needles, within the thickness of the wall and resting upon the piers. The new wall can now be built on the top of this girder until the old work is met, cement mortar being used, and the work carefully pinned up. As soon as this has set the wedges may be gently released, and another day allowed to elapse to enable the old wall to take its bearing upon the new work and the girder before they are entirely removed. Finally, the holes through which the needles had passed are made good, and if the work has been carefully done there ought to be no sign of settlement.

Under-Pinning.—When a building has given signs of settlement due to a bad foundation, or when it is desired to extend it downwards by excavating a cellar, resort has to be had to the process known as underpinning. This in some respects is similar to needling, save that no needles or timber struts are required. An excavation is made along one side of the foundations to the necessary depth, and for a length of not more than 5 feet, and the old foundations are undermined, as shown in Fig. 249A, for a length of about 4 feet and to a width equal to the calculated width of the new foundation. The superincumbent wall is carried by the adhesion of its mortar across the gap, and the new wall, to a length of 4 feet, is built up in the

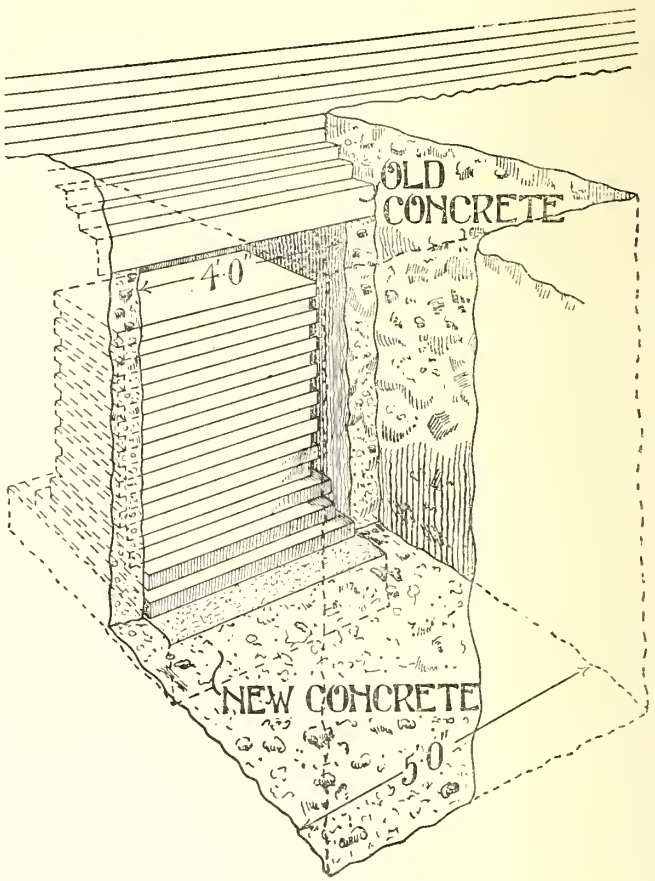


Fig. 249A.

trench upon a new foundation until it meets the old wall. All this is done in cement mortar, and the new work is pinned to the old, if necessary, with slate wedges in cement, care being taken that these are driven very gently. Sometimes the work is done continuously, 4 feet at a time, but more often piers are carried down in this way, each 4 feet apart from its neighbour; and when all these have been built and pinned up they act the part of Needle Shores, and the intervening earth can then be removed and the gaps made good one by one.

CHAPTER XVI

TERMS RELATING TO CARPENTRY

The term "Carpentry" is taken in the present Volume, in its strictest sense, to represent the timberwork connected with the framing of roofs, floors, partitions, and other work of a purely *constructional* nature; while the framing of doors, windows, and other ornamental features is to be treated in the next Volume under the head of Joinery.

These two trades are so often coupled together that the terms "carpenter and joiner" have become synonymous in the minds of many, and, indeed, not without reason, for it is by no means unusual to find the same man practising both trades. This is, however, a mistake, as it is conducive of bad and expensive work,—for a carpenter who can produce such highly finished work as is necessary for joinery is as rare as a joiner who is rapid and not unnecessarily exact when working upon the larger scantlings with which the carpenter frames his structures.

Great advantage is to be gained, however, by coupling these trades together in a Specification, as they go hand in hand in so many instances; and it is for this reason that framing of an ornamental character, together with "grounds," "fixing blocks," "wood slips," and other necessary adjuncts of joinery work—which it is the duty of the carpenter to properly fix—have been omitted from the present Volume, in order that they may take their places with those details of construction with which they are more closely connected.

Timber.—The timber used principally for carpenter's work in England is that known as northern pine, red pine, Baltic fir, or red fir. It is grown in Northern Europe generally, and is shipped to London from the ports of Riga, Dantzig, Memel, and Stettin. Much of this timber is sent over in balk—that is to say, in logs which have been roughly squared with an axe. Timber shipped from Memel and Dantzig is frequently sawn die square before shipment, as also is American pitch-pine. The size of these *squared timbers* averages about 13 inches square, although they frequently run as large as 21 inches square, and they vary from 18 to 45 feet in length. Logs under 12 inches square are called "*undersized*," while logs 8 inches square and under are distinguished as "*balks*."

These large timbers are usually sawn up into convenient sizes for building purposes, and there are a number of technical names applied to various sized timbers so produced.

Planks are pieces of timber from 1 to 4 inches in thickness, from 8 to 20 feet long, and *over* 9 *and under* 11 *inches wide*.

Deals are of the same length and thickness as planks, but are *over* 7 *and under* 9 *inches in width*.

Battens are of the same length and thickness as deals and planks, but are *under* 7 *inches in width*.

Ends.—Battens, deals, and planks when under 8 feet in length are termed ends, and when it is required to differentiate more distinctly they are termed *Batten ends*, *Deal ends*, and *Plank ends* respectively.

Boards.—Ends under 3 inches in thickness are termed *Boards*.

Scantling.—A piece of timber cut to a small size, as for a stud rail or bearer, is termed a scantling.

The term *Scantling* is also used synonymously with *dimension*.

Sawing of Timber.—Timber is often sawn at the port of shipment into planks, deals, and battens, but some sawing is still performed in timber-yards and workshops in this country. This sawing is done by machinery, either by means of circular saws or bow saws.

Circular Sawing.—In this method of sawing a roughly trimmed or "squared" log is placed upon a slowly moving bench, which carries it against a rapidly revolving toothed circular blade. This cuts off one plank at a time, the width of the plank being regulated by means of a vertical guide placed on one side and parallel to the saw. This process is usually considered too slow for sawing large timbers, in which case a mechanical bow saw is used.

Bow Sawing.—The bow saw is composed of a number of toothed blades fixed vertically in a stout steel frame, the distance between the blades being regulated to the thickness of the planks into which it is desired to saw the squared timber. The frame works in a vertical guide on either side, and is moved up and down by means of a crank pivoted at one end to the frame and at the other to a heavy wheel, which in its turn is driven by steam or other power.

The timber to be sawn by a bow saw is placed upon a travelling carriage, which is geared to move slowly against the saw.

The rate of "feed," or rate at which the log is carried past the saw, can be regulated according to the density of the wood to be sawn.

CHAPTER XVII

JOINTS IN CARPENTRY

It is a matter of considerable importance, in the framing of timber structures, to form each joint in such a manner that it may perform its particular office in the best possible manner. The functions performed by joints are very numerous, and it therefore requires a considerable amount of thought to select the joint best suited to any particular purpose, and to proportion its parts correctly.

The joints used in carpentry may be classified into three groups, as shown in the following table :—

3. The area of each part of the joint and its fastenings must be proportioned to resist the maximum stresses brought upon them.

4. The joints and fastenings must be so proportioned and fitted as to cause the stresses to be spread as uniformly as possible over their sections.

5. The joints must be formed so as to be affected as little as possible by shrinkage or expansion of the wood.

	Used for.	Technical Names of Joints employed.
Lengthening Joints.	Lengthening ties.* Lengthening struts.†	Lapped (nailed, bolted, A, Fig. 250 ; strapped, B, Fig. 250). Scarfed (plain, A, B, C, D, E, Fig. 251 ; bolted, F, Fig. 251). Fished, A, B, C, D, E, F, Fig. 252.
	Lengthening beams.‡	Fished, Fig. 252.
	Lengthening wall-plates. Pole-plates, etc.	Halved, A, B, C, Fig. 253. Bevel halved, D, E, Fig. 253. Dovetail halved, F, Fig. 253. Keyed, G, Fig. 253. Wedged, H, Fig. 253. Screwed, K, Fig. 253.
Bearing Joints.	Supporting beams on plates and beams on beams.	Abutted, A, Fig. 254. Housed, F, G, Fig. 254. Notched, B, C, Fig. 254. Cogged, H, K, L, Fig. 254. Mortised and tenoned, A, B, C, Fig. 255. Tusk tenoned, A, B, C, Fig. 256. Housed tenoned, Fig. 257.
	Supporting beams on posts and posts on beams.	Cleated, A, B, C, Fig. 259. Wedged tenoned, A, Fig. 260. Mortised and tenoned, A, B, Fig. 258. Bridled, C and D, Fig. 258. Dovetail tenoned, B, Fig. 260. Turk tenoned, Fig. 261. Housed, Fig. 261.
	Supporting ends of inclined timbers.	Bird's-mouthed, A, Fig. 263. Cleated, B, Fig. 263.
Connecting Joints.	Connecting struts with ties. Connecting struts with struts. Connecting ties with ties.	Abutment-plate, A, Fig. 264. Plain abutment, B, Fig. 264. Tenoned abutment, C, Fig. 264. Bridled, D, Fig. 264.

* The term *tie* is applied to members of a frame structure which have to resist a tensional stress

† The term *strut* is applied to members of a frame structure which have to resist a compressional stress.

‡ The term *beam* is applied to members of a frame structure which have to resist a transverse stress

Principles of Joint Making.—In making joints in woodwork the following five principles should be borne in mind :—

1. All cutting must be performed in such a manner as to weaken the timbers as little as possible.

2. Where possible, abutting surfaces should be perpendicular to the pressures brought upon them.

Lengthening Joints

Joints to lengthen Ties and Struts.—

Lapped Joint.—This joint is of a very clumsy appearance, and is only used in work of a temporary nature or in small timber framings hidden from view. It is formed by overlapping the ends of two pieces of timber,

and fixing them by means of nails or bolts as at A, or by straps as at B, Fig. 250. Nails are used when the timbers are small. It has been found also in practice that a bolted joint is more suitable for resisting a tensile stress than a strapped joint, the latter being a more satisfactory joint when the timbers are in a state of compression.

When forming a joint, experience is usually relied upon as a guide in proportioning the various parts, and when experience is lacking they can be calculated. The timbers in Fig. 250 are in a state of tension, which causes a stress in the sections of the bolts along the line AB, similar to that caused by a pair of shears in

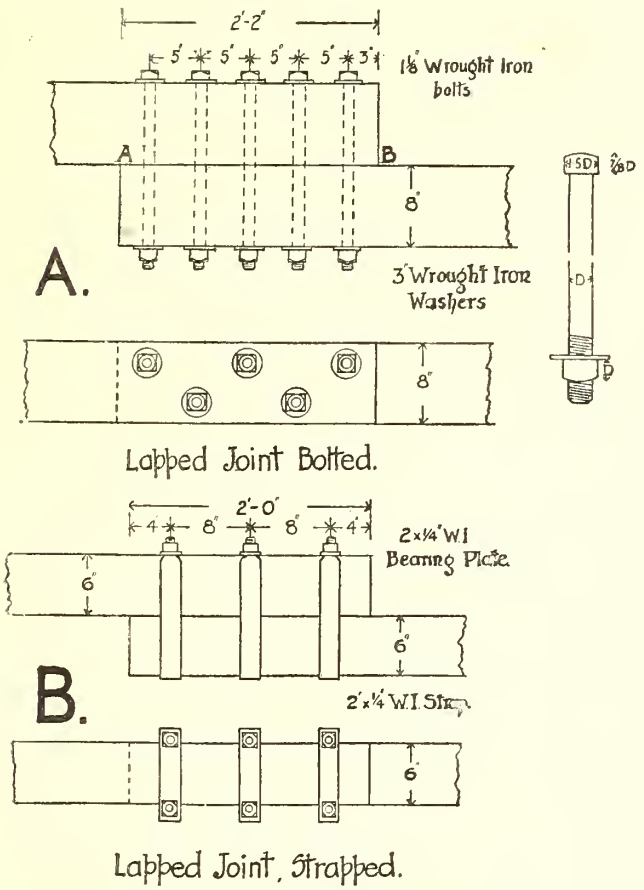


Fig. 250.

cutting a piece of paper. Such a stress is called a *Shear*, and the power of a bolt to resist it is directly proportional to its sectional area. To form a joint of uniform strength it is necessary that the ultimate resistance to shear of the metal in the bolts shall be equal to the ultimate resistance to tension of the timber.

Suppose the timbers at A, Fig. 250, to be Baltic fir, then by the table at the end of this Chapter it is seen that this material has an ultimate resistance to tension of 4000 lbs. per square inch. The bolts are made of wrought iron, and offer an ultimate resistance to shearing of 44,800 lbs. per square inch So that for a joint of uniform strength the total sectional area of the bolts must be $\frac{4000}{44800}$, or $\frac{1}{11}$ (roughly), of the effective sectional area of the timber. Now the question arises as to the size of the bolts, which is usually determined by some such rule of thumb as the following: For timbers of 10 square inches effective section use $\frac{1}{2}$-inch bolts, and add $\frac{1}{16}$ inch to the diameter of the bolts for every additional 5 square inches to the section of the timbers. At A, Fig. 250, the effective sectional area of the timbers is something less than 64 square inches, so that the bolts required will be $1\frac{1}{8}$ inch in diameter.

The effective sectional area of the timbers, *i.e.* the area left after a bolt hole has been made, is $8 \times (8 - 1\frac{1}{8}) = 55$ square inches, and the area of metal required in the bolts is $\frac{55}{11} = 5$ square inches.

$$\text{Now, the area of each bolt} = \frac{\pi \times \text{diameter}^2}{4} \text{ sq. inches.}$$

$$= \frac{22 \times 9 \times 9}{7 \times 4 \times 8 \times 8} \text{ sq. inches.}$$

$$\text{Therefore the number of bolts required} = \frac{5 \times 7 \times 4 \times 8 \times 8}{22 \times 9 \times 9}$$

$$= 5 \text{ nearly.}$$

One bolt hole should be bored and the bolt inserted and tightened up before the other holes are bored, in order to ensure that the holes in the various timbers coincide exactly. This applies to all bolted joints.

The distance between the bolts should not be less than 5 inches, although a greater distance is preferable, as it lessens the chance of the bolts cutting through the timbers, or the shearing out of the portion of the timber against which the bolts thrust. Where the width of the timber permits, the bolt should not be arranged in one line, but should be zigzagged as at A, Fig. 250, as this presents a greater area of wood to resist shear.

Scarfed Joint.—In this method of uniting timbers corresponding portions are cut away from the ends of each, and the remaining portions are overlapped and fitted together. This joint is used when appearance is the main object, for which reason great care should be taken in its designing and cutting, so that it may be as imperceptible as possible.

A good form of scarfed joint for resisting a tensile stress is shown in elevation at A, Fig. 251, and in isometric projection at B, Fig. 251. It will be seen that the timbers are considerably weakened by scarfing, the effective area in the case of A being that across either AC or BD. It is obvious also that if there is a tensile stress in the sections AC and BD, the section AB will be in a state of compression, and there will be a tendency for the timber to shear along the line BE. Now, from the table at the end of this Chapter—assuming this joint is formed of Baltic fir—the ultimate resistance to tension and compression are 4000 and 5000 lbs. per square inch respectively, then the distances AC, AB, and BD must be in the proportion of 5000 : 4000 : 5000, or 5 : 4 : 5. Therefore CA and BD are each equal to $\frac{5}{14}d$, while $AB = \frac{4}{11}d$. Again, the ultimate

resistances of Baltic fir to tension and shear are 4000 and 600 respectively. Hence BE = 7 AC, nearly.

There is no fear of the joint failing at the wedges, as these are formed of good pieces of oak, which has a much higher crushing resistance than Baltic fir.

At C, Fig. 251, another very good form of scarfed joint is shown, which is more easily worked than the one shown at A. In this case the joint has to be designed so that the total resistance to shear along AB and CD may be equal to the resistance to tension in EF. The wedges WW are also in shear, and their width is usually made about equal to EF, and inserted with the grain at right angles to the pressure. According to the table, the safe resistance to shear in oak

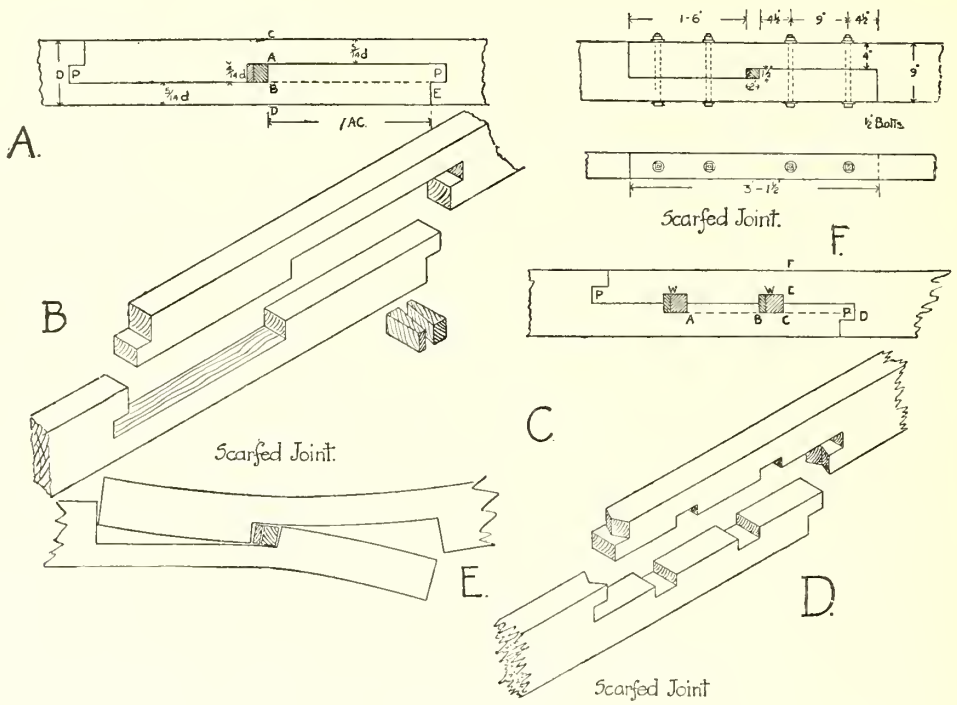


FIG. 251.

across the grain is 3000 lbs. per square inch, but this is for larger-sized average timbers, while wedges are carefully selected pieces which can be made smaller in consequence than the size demanded by theoretical calculations. Squared joggles of oak are sometimes used, but wedges are preferable, as they can be tightened, thus ensuring the assistance of every portion of the joint.

The ends of the scarfed joints are sometimes cut as shown at D, with the object of preventing lateral motion in the timbers, but it is very doubtful whether such cutting has any compensating advantages over the labour expended upon it.

The reason for forming the projecting portions P, as shown at A, B, and C, Fig. 251, is to prevent the joints from opening as at E, but their place is often taken by bolts, as at F. When bolts are used the scarf can be made much shorter, and the wedges need only be deep enough to draw the joint up tightly before the bolts are inserted.

Fished Joints.—When it is desirable to join two timbers without reducing their section to the extent shown in Fig. 251, a joint known as a *Fished Joint*, and formed as shown in Fig. 252, is used. The simplest form of fished joint is that shown at A, Fig. 252. It is formed by butting the ends of the timbers and bolting wooden *fish-plates* on to two parallel sides.

The distances EF and GH should together be equal to FG, so that the combined sectional area of the plates may be equal to that of the joined timbers.

The size of the bolts may be taken from the same rule as was given for lapped joints.

It will be noted that at A, Fig. 252, the bolts tend to shear along the *two* planes AB and CD, for which reason they are said to be in *double shear*. It is clear, therefore, that this joint requires half the number of bolts that would be used for a lap joint in the same timbers, on each side of the line EF; or, which amounts to the same thing, this joint requires the same number of bolts as a lapped joint. Thus if A, Fig. 250, and A, Fig. 252, be compared it will be seen that the lapped joint has five bolts, while fished joint has six, the total being increased by one in the latter case to equalise the number on each side of the joint.

Sometimes the fish-plates are *tabled*, *i.e.* they have projecting portions formed on them which fit into corresponding indents in the timbers joined. The use of such tables is shown at B, in which case it is found by calculation that it would require three and a quarter 1-inch bolts approximately. Instead of using

four bolts, three only are employed on each side of the joint, and the strength of the odd quarter bolt is supplied by the resistance to shear along the plane CD.

Keys and wedges are sometimes used for the same purpose as tables, corresponding indents being formed in the jointed timbers, and the fish-plates, as shown at C and D, Fig. 252. In jointing small timbers it is very doubtful whether much real advantage is obtained by the use of such wedges, but in very large timbers with long fish-plates, especially when subjected to a transverse strain, wedges add considerably to the stiffness and strength of the joint. By using iron plates a less clumsy joint may be formed, as shown at E. Sometimes the ends of iron fish-plates are turned down into corresponding indents, as shown at F, the object of such a joint being the same as that obtained with a tabled wood fish-plate.

Bevelled Halved Joint.—A more secure joint is formed by bevelling the adjoining surfaces of the halvings, thus producing a joint known as a *Bevelled Halved Joint*, and shown at D, Fig. 253. In these halved joints it is always desirable to place a joist or bring weight to bear upon them, as this checks any tendency of the plates to move either longitudinally or transversely.

A bevelled halved joint between two plates meeting at an angle is shown at E.

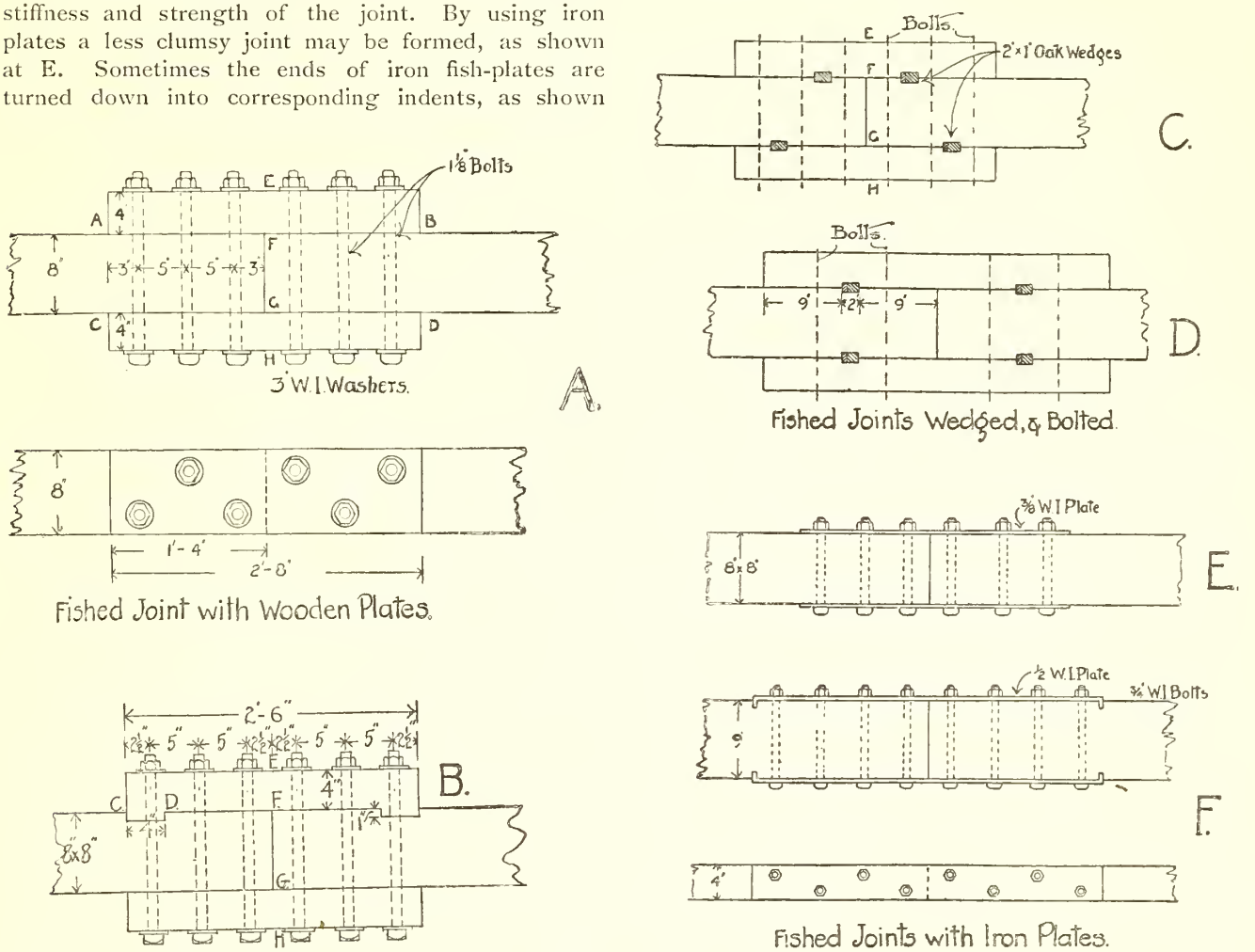


FIG. 252.

JOINTS FOR LENGTHENING WALL-PLATES, ETC.—

Halved Joint.—The most simple joint for connecting two portions of a wall-plate is shown at A, Fig. 253. It is made by cutting away half the section of the adjoining ends, or *Halving*, as it is technically termed. The methods of forming this joint when the two portions of the plate meet or cross at an angle are shown respectively at B and C.

Dovetailed Halved Joint.—For joining plates at an angle the dovetailed halved joint shown at F is efficient, on account of its simplicity of formation and its power of resisting the action of dislodging forces. It should be formed of well-seasoned timber, as any shrinkage in the width of the dovetail loosens the joint.

Keyed Joint.—Sometimes the plates are jointed by means of a hard-wood key formed as shown at G, and drawn tight by means of wedges. Although this joint serves its purpose in a satisfactory manner it is un-

necessarily expensive. It is used to a great extent in joinery work.

Wedged Joint. — This joint, which is shown at H, like the keyed joint, is rarely used in carpenter's work, as it is unnecessarily complex for the simple function it has to perform.

Screwed Joint. — A very useful joint is formed by butting the ends of the plates and securing them by means of a hand-rail screw, as at K.

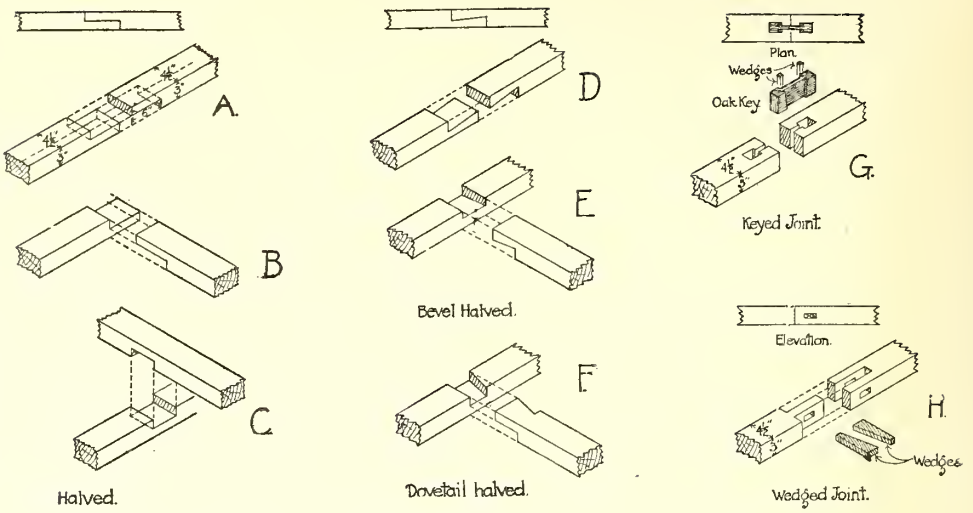


FIG. 253.

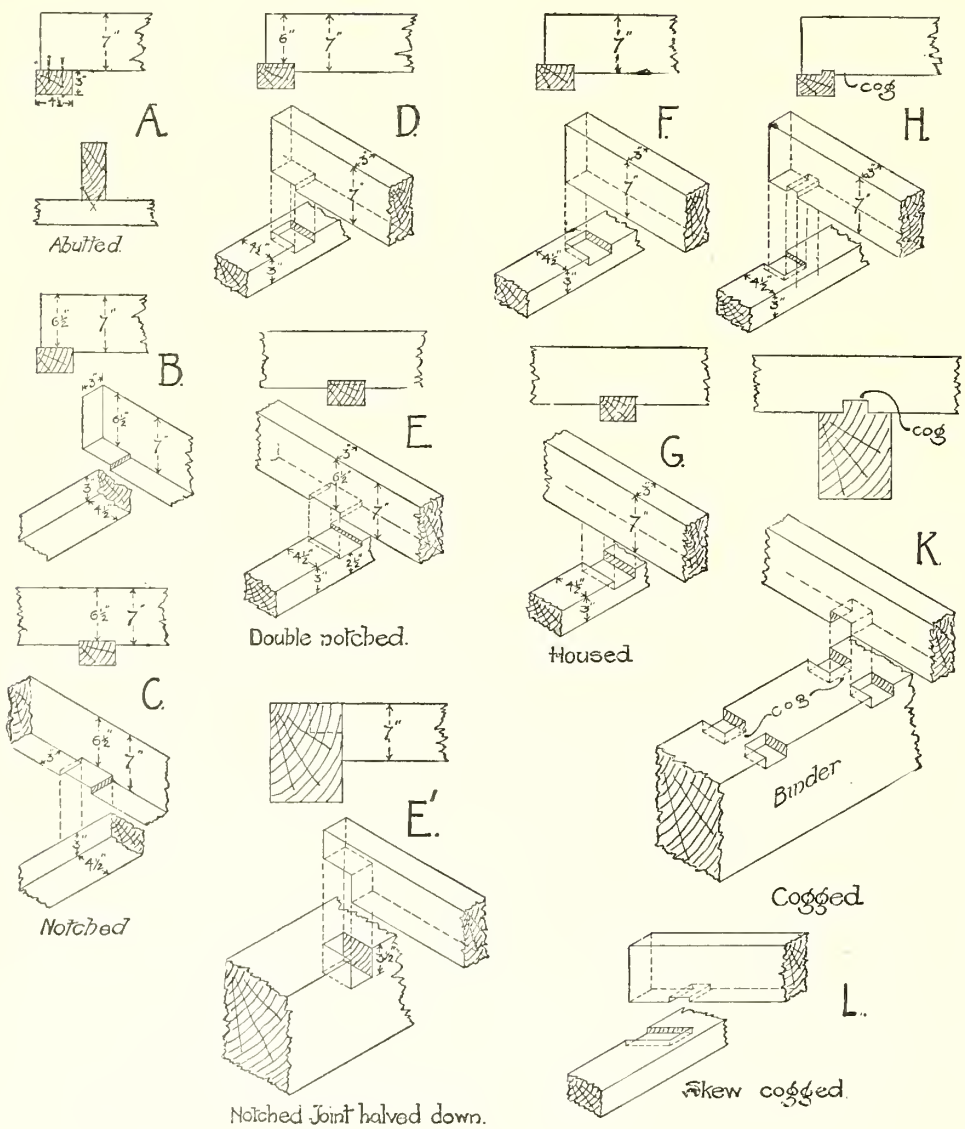


FIG. 254.

BEARING JOINTS

JOINTS FOR SUPPORTING BEAMS ON PLATES OR BEAMS ON BEAMS.—

Abutted Joint.—The simplest way of supporting a beam upon a wall-plate is by allowing the former to rest upon the upper surface of the latter, as at A, Fig. 254. Any tendency to dislodgment is prevented by driving spikes of iron through the sides of the joists, thus securing them to the plate.

Notched Joint.—A rather more secure joint is formed by *notching* the end of this joist, *i.e.* by taking out a rectangular portion from the under side of the joist so that it fits over the plate, as shown at B. When a joist is carried over a plate or a cross beam a notched joint is formed, as shown at C. Another form of notched joint, sometimes called a *double-notched* joint, is shown at D and E, where

a portion is notched out of the plate as well as the joists. In floor construction it frequently becomes necessary to make the upper surfaces of the joists and cross beams which support them on the same level. This is often done by means of a double-notched joint, having half the depth of the joist notched out of the joist and an equal amount notched out of the cross beam, as at E. Such a process is called "Halving down."

Housed Joint—Another simple joint for the end of a beam is shown at F and G, the end of the joist being left uncut and simply fitting into a notch in the member upon which it abuts.

Cogged Joint.—The most satisfactory joint between a beam and plate or a joist and cross beam is that known as the *Cogged Joint*, shown at H and K.

The method of forming this joint when a joist passes over a cross beam is shown at K, a piece the width of the joist being notched out of each edge of the cross beam, leaving a solid portion in the centre of the upper surface over which the joist is notched. When the end of a joist is to have a notched bearing it is more economical in labour to form the *cog* at the outside edge of the plate at H. When the plans of rooms are not rectangular, *skew-cogged* joints, such as are shown at L become necessary. The advantage of this joint is that it makes a wooden framework very stiff by anchoring the walls and cross beams together.

Mortised and Tenoned Joints.—When a beam has to be attached to the side of a cross beam some form of tenoned joint is employed. At A, Fig. 255, is shown a ceiling joist with a tenon cut upon it, and a corresponding mortise cut in the cross beam which is to support it. Projecting portions P are usually formed on the ends of ceiling joists to go under the cross beams, to the under side of which they may be spiked for additional bearing strength, or to afford a suitable attachment for the laths of a lath and plaster ceiling.

Chase Mortise.—It sometimes happens that the cross beams or *binders* of a floor have to be fixed before the joists, or that a decayed joist has to be renewed, and it is obviously impossible to do this when the mortices are made as shown at A.

This difficulty is overcome by cutting a slight bevel upon the upper surface or cheek of the mortise, as shown at B, Fig. 255, which enables the tenon at one end to be inserted when the joist is in an inclined position. This done, the tenon at the other end can be dropped into a *Chase mortise*, which is cut as shown at B, Fig. 255. The same result may be attained by means of a horizontal chase mortise, and the joist is inserted as shown at C. It should be noted that the portion projecting beneath the cross beam cannot be used in the case of B, its place being taken by a fillet nailed to the under side of the binder.

Tusk-Tenon Joint.—A very useful bearing joint for framing timbers together is shown at A, Fig. 256. The exact proportions of the various parts of this joint might be theoretically determined, but the relative values determined experimentally for the safe resistances of timber to tension, compression, and shear vary so considerably that the dictates of experience are usually followed. The joint, with its parts pro-

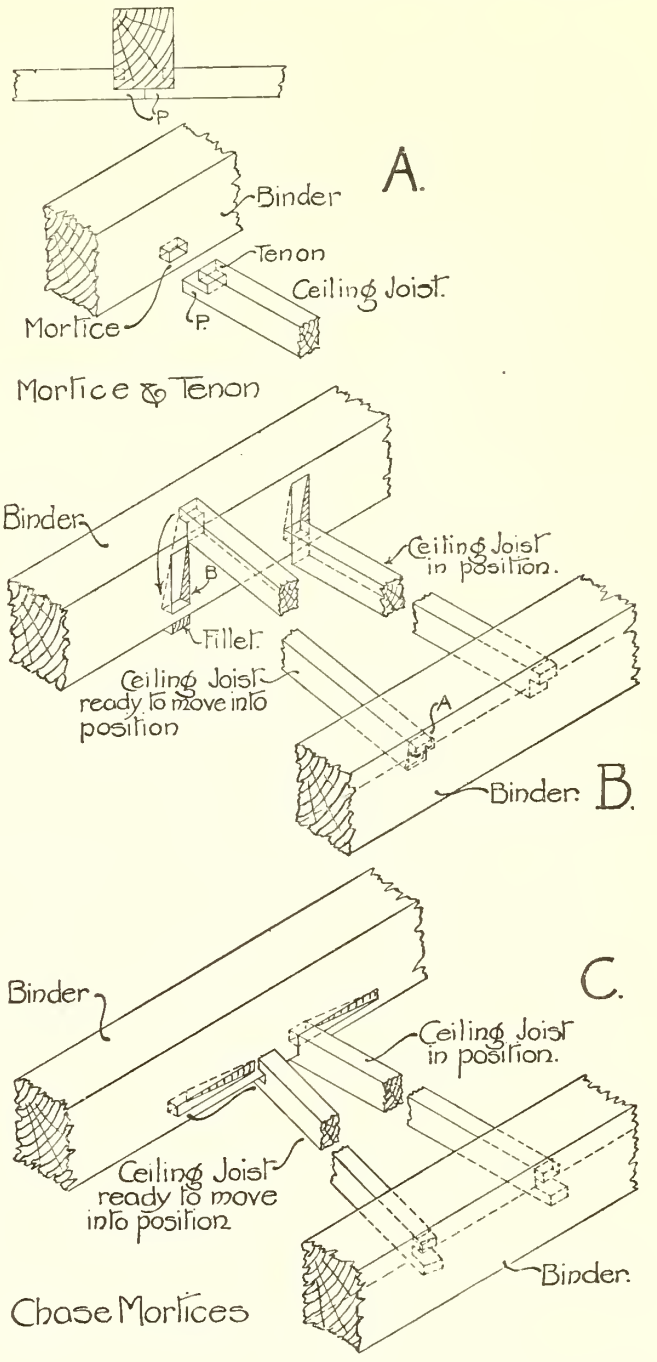


FIG. 255.

portioned as at A, Fig. 256, is the one most used in practice. The tenon is carried right through the mortised member, and should be made to project at least two-thirds of the depth of the beam, so that a portion of it will not shear out when the wedge is driven home.

It is often undesirable that the tenon of a tusk-tenon joint be carried right through the member into which it is framed, in which case short tenons are used, which are kept in position by means of iron spikes or wooden pegs, as at B. Sometimes the tenon is

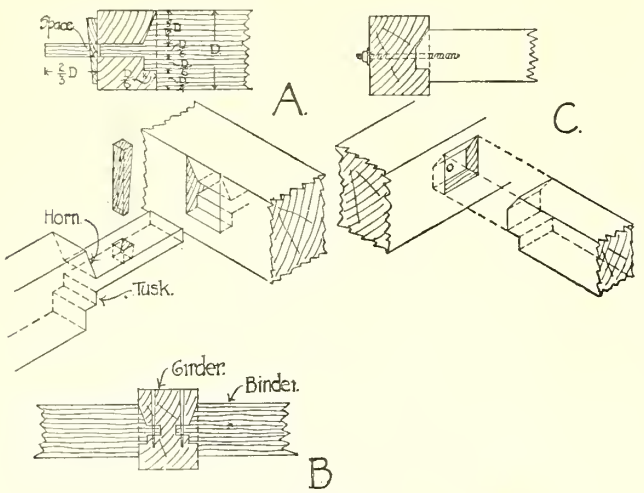


FIG. 256.

dispensed with altogether, and its place taken by a hand-rail screw, as at C.

Dovetailed and Housed Joint.—Another joint used for the same purpose as the tusk-tenon joint is the dovetailed housed joint, which is formed as shown in Fig. 257. This joint slightly weakens the notched beam,

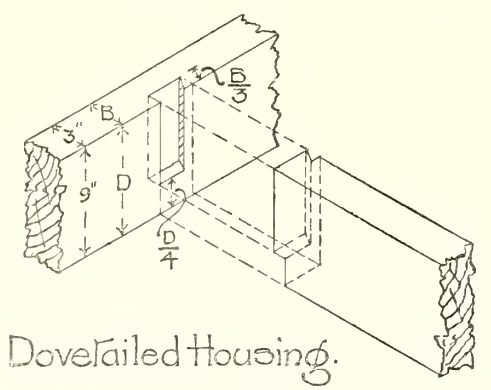


FIG. 257.

but it has the advantage of enabling the dovetailed ends of joists to be slipped into position after the beam has been fixed.

JOINTS FOR SUPPORTING BEAMS ON POSTS, AND POSTS ON BEAMS.—The following three forms of joints are used both at the foot and head of posts:—

Stub-Tenoned Joint.—The simplest form of beaming joint for a beam resting upon the head of a post or for a post resting upon a beam is that known as a *Stub-Tenoned Joint*, as at A, Fig. 258. The width of the tenon is made about one-third the width of the post. It projects a distance equal to its width, and springs from one plane called the *Shoulder*. A mortise is cut in the beam slightly deeper than the length of the tenon, so that all the weight is brought upon the shoulder and not upon the tenon.

Tenoned and Pinned Joint.—A very excellent form of joint, much used for heavy timbers, especially in *Half-Timbered Construction*, is shown at B, Fig. 258, where a tenon is cut at the end of the post inserted in a mortise of corresponding dimensions, and secured by means of oak pins.

A Bridled Joint is formed by cutting away a portion from the centre of the end of the post, and this fits

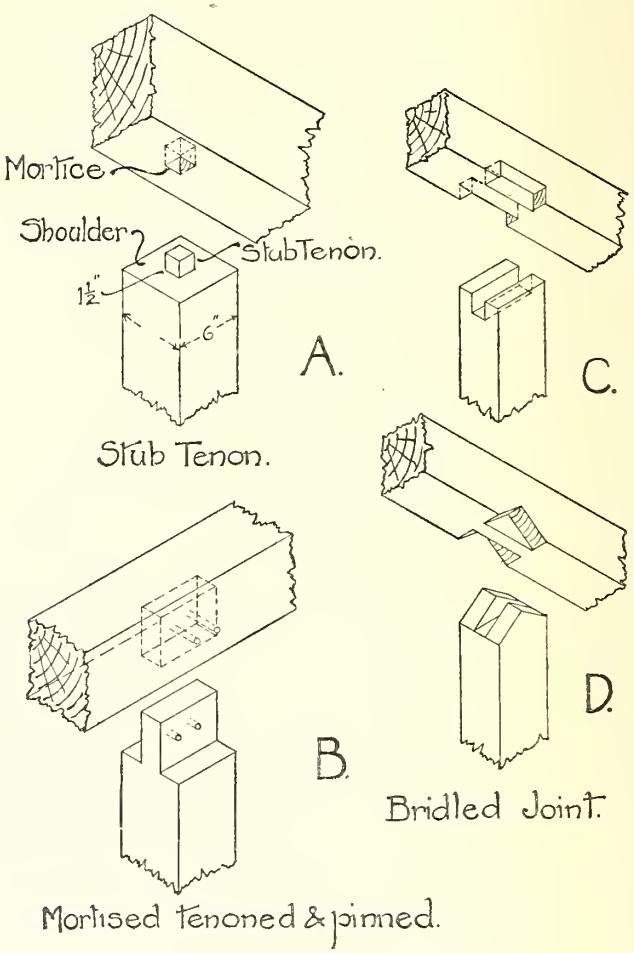


FIG. 258.

over a corresponding cog formed on one face of the beam, as at C. Sometimes the end of the post is formed as shown at D. This form of joint is preferred by many, as bad workmanship can be detected, while in a mortised and tenoned joint bad workmanship on the tenon is concealed once the joint has been fixed in position.

When the beam is supported on the side of a post, as is the rail of a fence and the straining beam of a queen post roof truss, one of the following joints is used:—

Cleated Joint.—A strong though somewhat clumsy

joint is formed by bolting or railing a block of wood—called a *Cleat*—to the side of the post, and resting the beam on top of it, as at A, B, and C, Fig. 259. Lateral

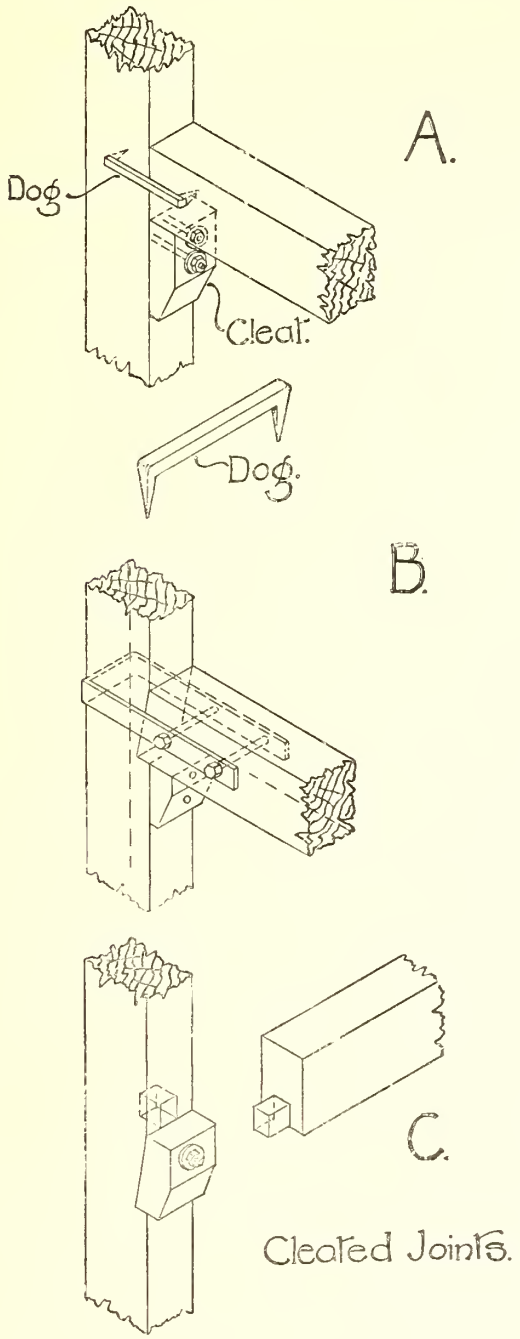


Fig. 259.

motion in the beam is prevented by the use of dogs, straps, bolts, or stub tenons.

Wedged-Tenoned Joint.—When a beam has no very great load to carry, but is liable to become dislodged, a tenon and mortise is often used, two opposite cheeks of the mortise being slightly splayed to permit wedges to be driven in on either side of the tenon, thus making the latter secure, as shown at A, Fig. 260.

Dovetailed-Tenoned Joint.—Another tenoned joint which offers great resistance to drawing is the dovetailed-tenoned joint, shown at B, Fig. 260, in which

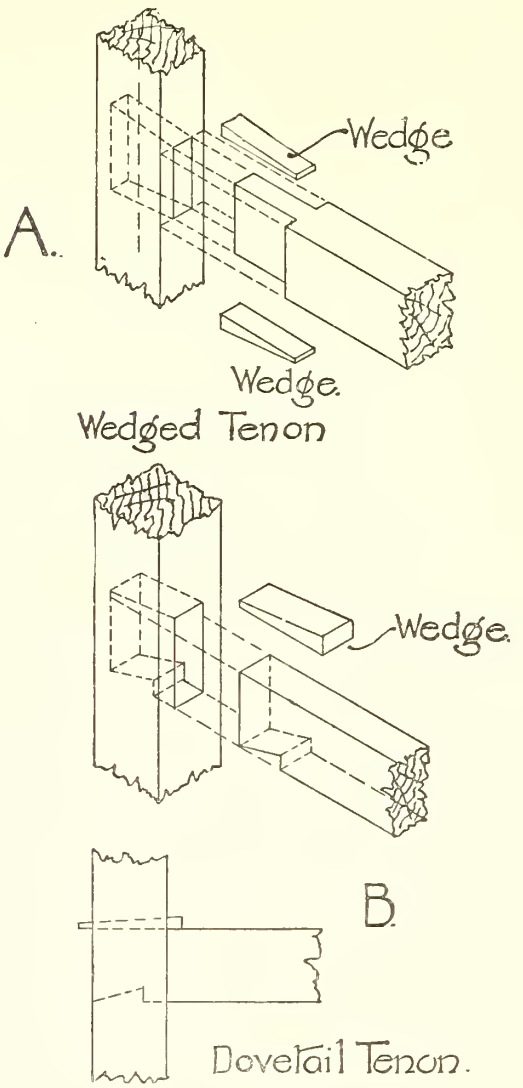


Fig. 260.

the whole section of the rail is housed into the post to give additional bearing power to the joint.

Tusk-Tenoned Joint.—A form of tusk-tenon joint is a suitable means of attachment of a beam to the side of a post where fair bearing power is required. Instead of cutting the horn, tenon, and tusk out of the whole section of the beam, they are cut out of a tenon about one-third the width of the beam, as in Fig. 261. The joint is prevented from drawing by means of an oak pin passing through the cheeks of the mortise and the tenon.

The method of inserting oak pins is as follows: A hole is bored through the tenon at a convenient distance from the shoulder, and at the same distance from the cut face of the post a hole is bored through the cheeks of the mortise. The tenon is now inserted

in the mortise, and a *Draw pin*—a tapered peg of iron—is driven in the bored holes. This draws the shoulder tightly against the face of the post. The draw pin is now removed and replaced by a hard-wood peg.

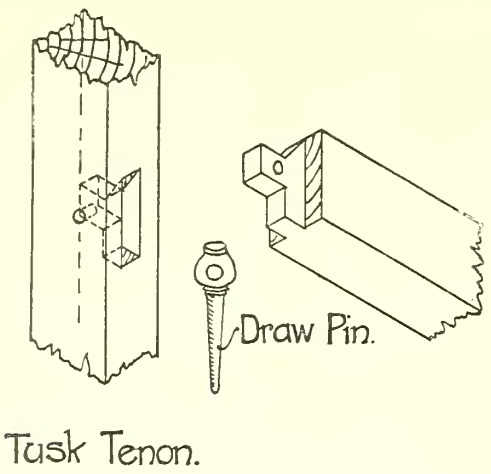


Fig. 261.

Housed Joint.—A joint very commonly used for supporting the rails of fences is formed by cutting a mortise of the shape of the rails right through the post, as shown in Fig. 262. The ends of the rails are splayed and inserted in these mortises, so that they

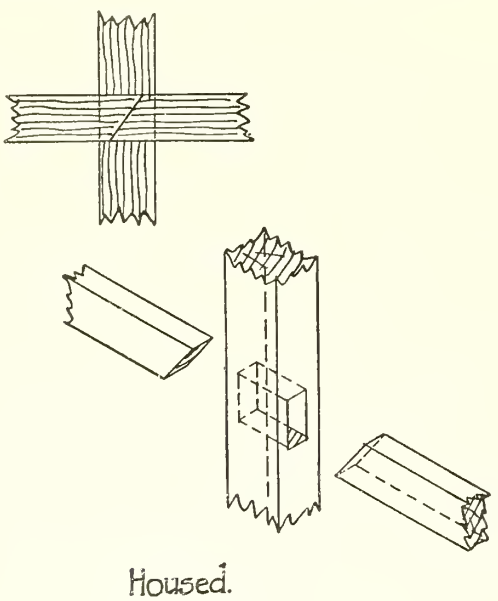


Fig. 262.

overlap, and are then secured by means of nails or pegs driven through the cheeks of the mortise. This joint gives a maximum bearing capacity to the rails, and enables all the posts of a fence to be set up before the nails are inserted.

Joints for supporting Ends of Rafters.—

Bird's-mouthed Joint.—When an inclined timber bears upon a wall-plate the end of the former has an angular portion—called a *Bird's-mouth*—cut out of it so that it fits over the latter, as at A, Fig. 263. There is danger when this joint is used of the bird's-mouth being cut so deep that the strength of the timber is impaired. Serious accidents have happened, such as the collapse of a grand stand on a football ground, from too

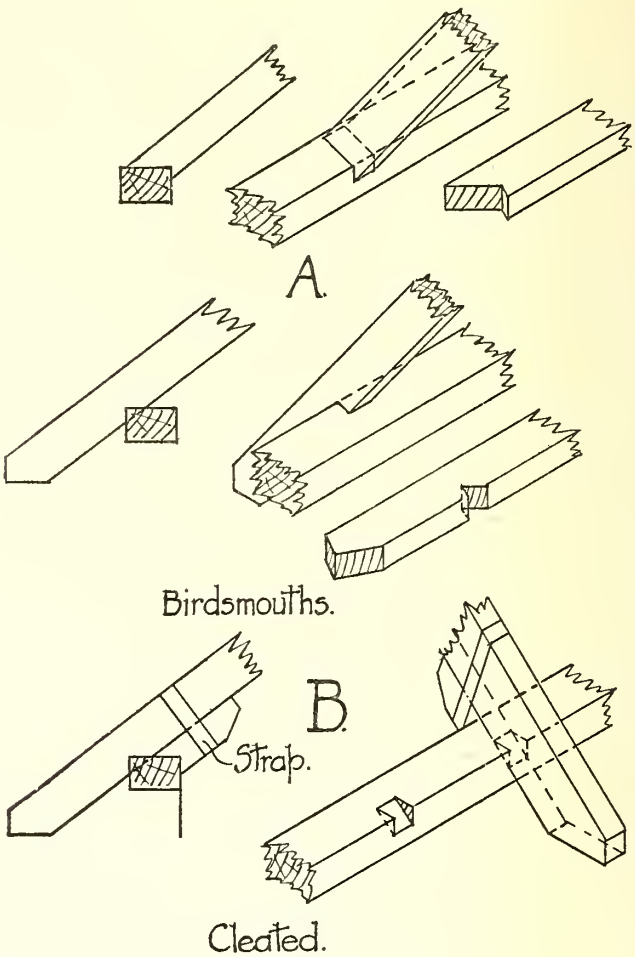


Fig. 263.

deeply cut bird's-mouths. A good way of supporting an inclined timber is by bolting or strapping a cleat on to its under side, as at B.

Connecting Joints

Joints for connecting Struts with Ties.—

Abutment Plate Joint.—This joint is formed, as shown at A, Fig. 264, by bolting a plate of wood on to the end of the tie against which the foot of the inclined member abuts. The bolts connecting the plate to the tie—which are in single shear—should contain sufficient metal to resist a thrust equal to the tension in the tie.

Plain Abutment Joint.—In this joint an abutment is formed for the inclined member by cutting a triangular section out of the tie with one face at right angles to the direction of the inclined member, as seen at B, Fig. 264.

Tenoned Abutment Joint.—A joint, similar to that shown at B, but having a tenon formed as shown at C, is called a tenoned abutment joint. In this joint, as in all abutment joints, the distance *ab* is made equal to about half the depth of the inclined member. The other parts are proportioned as shown.

Bridled Joint.—Another satisfactory joint for the connection of ties and struts is the bridle joint, shown at D.

In all these joints the inclined members are prevented

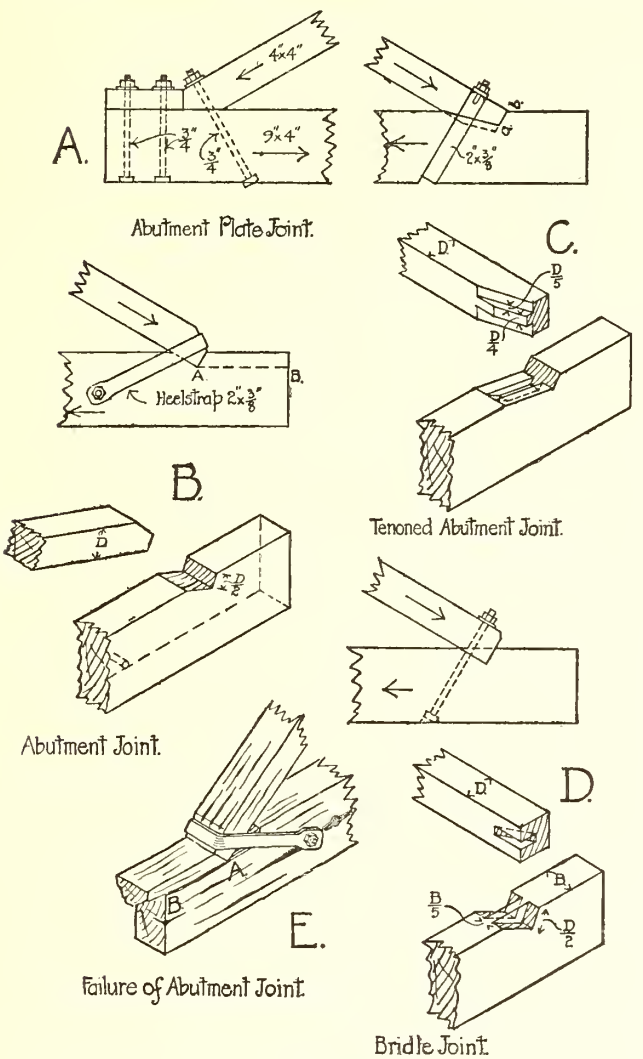


FIG. 264.

from becoming dislodged by means of bolts and straps. Straps passing right round the tie and strut are most suitable, as they do not tend to split the timbers as bolts do.

At E is shown a type of heel strap which is apt to cause the failure of a timber framework. It should not be used unless the timber is good and thoroughly well seasoned, so that there is no likelihood of a split, such as shown at E.

Fig 264 also shows how an abutment or bridle joint may fail by the shearing of the end of the tie. To prevent this, the length AB should be calculated by the following formula :—

$$T = \text{safe resistance to shear along AE} = \frac{AB \times b \times S}{\text{factor of safety}}.$$

Where T = tension in tie,
,, b = breadth of beam,
,, S = ultimate resistance of wood to shear per square inch.

Whence $AB = \frac{3\,T}{b \times S}$.

TENSILE, COMPRESSIVE AND SHEARING STRENGTH OF TIMBER.

Description of Timber.	Ultimate Tensile Strength in Direction of Grain.	Ultimate Compressive Strength in Direction of Grain.	Ultimate Shearing Strength	
			With Grain.	Across Grain.
SOFT WOODS.	Lbs. per sq. In.	Lbs. per sq. In.	Lbs. per sq. In.	Lbs. per sq. In.
Baltic fir	4000	5000	600	...
Cedar	2900	9700	...	1200
Pine, American yellow	2300	3000	375	3600
Pine, Oregon	...	...	375	2700
Pine, Kauric (New Zealand)	4500	5500	...	...
Pine, Pitch	4600	6000	...	...
Pine, American red	...	...	210	1500
Spruce	4000	4600	270	2250
HARD WOODS.				
Ash, English	3700	7,000	...	...
Ash, Canadian	5500	5,500	...	...
Beech	4800	8,500	...	...
Blue gum (Australia)	5400	10,000	...	...
Chestnut	8000	...	375	1200
Greenheart	9000	13,000	...	...
Mahogany, Spanish	3600	5,500	...	...
Oak, English, French, Tuscan, Modeno, Sardinian, American White	7300	6,000	450	3000
Ash, Dantzig	4400	6,600	...	...
Ash, Baltimore	3800	6,000	...	...
Teak	3300	9,000	...	...

These figures are the average results of experiments upon fair sized timbers, and a factor of safety of three for dead and six for live loads may be used in preference to Rankine's factors of four and eight, which were based on the results of experiments upon small, carefully selected specimens

CHAPTER XVIII

WOOD FLOORS

THE floors of small houses are usually constructed of wood, while in larger buildings, especially in factories or warehouses where heavy loads have to be carried, iron is used to a greater extent; while various combinations of iron, terra-cotta, and cement are used for constructing floors which are to be of a fire-resisting nature. This part of the subject is to be treated in a subsequent Volume. The beams which support the floor boards and ceiling of a room are called the *Naked Flooring*, and it is according to the disposition of these beams that floors are classified under three heads:—

1. Single-Joisted Floors.
2. Double-Joisted Floors.
3. Triple-Joisted, or Framed Floors.

1. SINGLE-JOISTED FLOORS.—When a floor is constructed of one series of joists, as in Fig. 265, it is called *Single-Joisted Floor*, and the joists are called *Bridging Joists*.

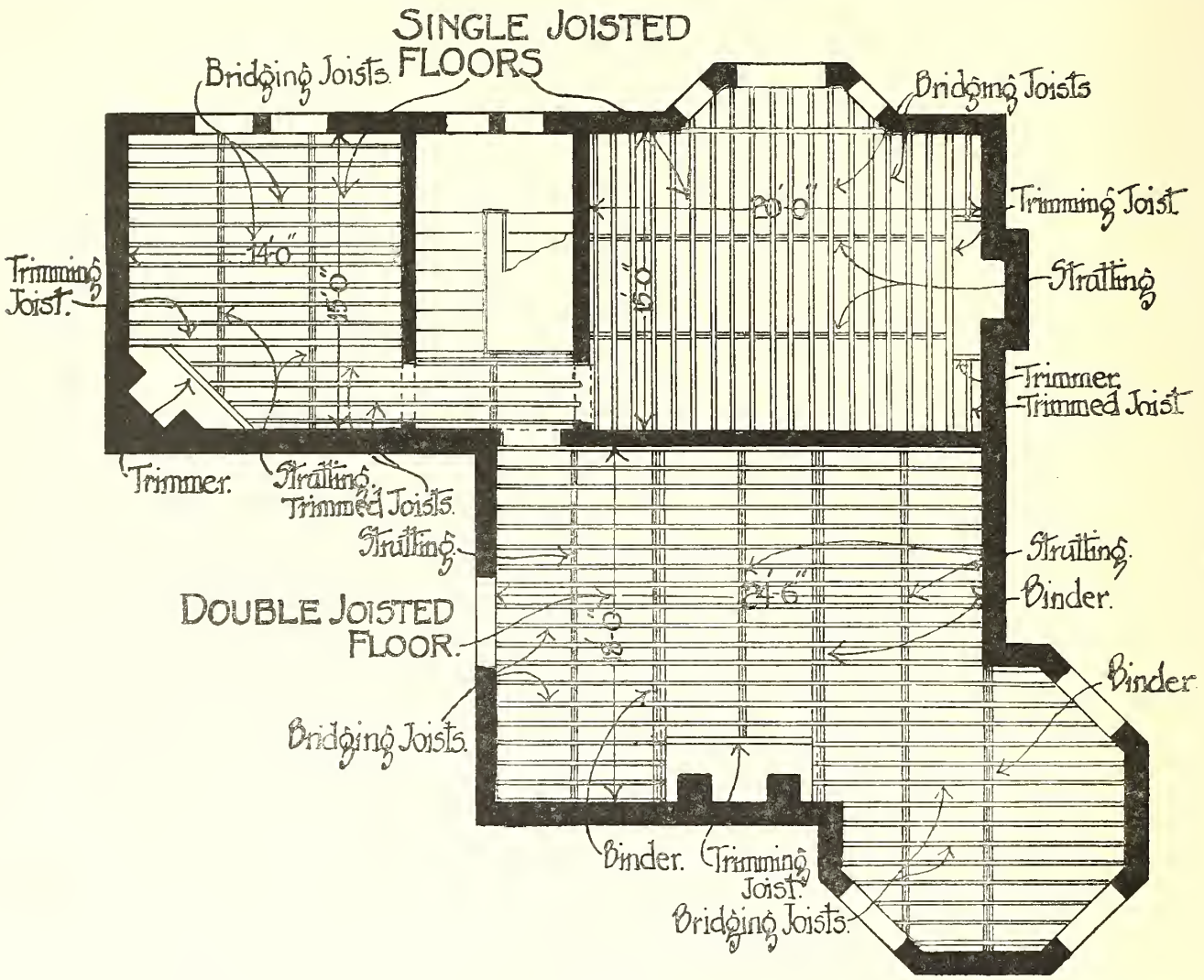


FIG. 265.

BRIDGING JOISTS are usually spaced at intervals of from 12 to 15 feet centre to centre, with their ends resting upon the strongest adjacent walls, *i.e.* walls containing the least number of openings. It is usually impossible to select walls without openings for sup-

porting the joists, and when there is little to choose in this respect, the joists are made to rest upon the walls which are the least distance apart.

Sizes of Joists.—In order to effect economy in timber, joists should be narrow and deep; but the breadth is governed by practical requirements, for it is found that joists under 2 inches thick are inclined to split when the floor brads are driven into them.

The depth of single joists is usually determined by some readily remembered rule, such as the following:—The depths of single joists in inches is found by dividing the span in feet by two and adding two.

This rule will be found quite satisfactory in practice, but where a very sound floor is required Tredgold's formula, given below, should be used. This formula gives larger scantlings than are usually used in practice, and indeed larger than the scantlings exhibited in Tredgold's own tables, a condensed form of which is here given:—

Girders (10 feet apart)
$$D = \sqrt[3]{\frac{L^2}{B}} \times 4.2 \text{ for fir, or } 4.34 \text{ for oak.}$$
$$B = \frac{L^2}{D^3} \times 74 \quad ,, \quad 82 \quad ,,$$

Ceiling joists (12 inch. centre to centre)
$$D = \frac{L}{\sqrt[3]{B}} \times 0.64 \quad ,, \quad 0.67 \quad ,,$$

Where L = Span in feet.
B = Breadth in inches.
D = Depth in inches.

Herring-Bone Strutting.—When single joists are employed for spans exceeding 8 feet they should be strutted to prevent them twisting or turning sideways. When the span exceeds 12 feet, two rows of strutting should be used, and so on, a row of strutting being added for each additional 4 feet in the span. Sometimes the strutting is more widely spaced, but the distance between the rows should never exceed 6 feet. The strutting usually employed is composed of pieces

Tables of Scantlings of Girders, Binding Joists, Bridging Joists, and Ceiling Joists of Different Bearings, from 10 to 30 Feet.

Based on Tredgold's Tables.

Length of Bearing.	Girders. 10 ft. Centre to Centre. 9 to 12 in. Bearing on Walls.		Binders. 6 ft. Centre to Centre. 4 to 6 in. Bearing on Walls.		Joists. 1 ft. Centre to Centre.		Ceiling Joists. 1 ft. Centre to Centre.	
	Depth.	Breadth.	Depth.	Breadth.	Depth.	Breadth.	Depth.	Breadth.
Feet.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
6	...	...	6	4	6	2	$3\frac{1}{2}$	2
8	...	...	7	$4\frac{1}{2}$	7	$2\frac{1}{2}$	4	$2\frac{1}{4}$
10	9	7	8	5	$7\frac{1}{2}$	$2\frac{1}{2}$	5	$2\frac{1}{2}$
12	10	8	9	$5\frac{1}{2}$	8	$2\frac{1}{2}$	6	$2\frac{1}{2}$
14	11	9	10	6	9	$2\frac{1}{2}$	...	...
16	12	10	11	$6\frac{1}{2}$	$10\frac{1}{2}$	$2\frac{1}{2}$	...	...
18	12	11	12	7	12	$2\frac{1}{2}$	...	...
20	13	11	13	$7\frac{1}{2}$	12	3	...	...
22	14	12	...	...	...	...	...	...
24	15	12	...	...	...	...	...	...
26	16	12	...	...	...	...	...	...
28	16	13	...	...	...	...	...	...
30	16	14	...	...	...	...	...	...

When the timbers are spaced at greater distances than are assumed in this table their sizes must be increased in proportion.

Tredgold's Rules for Sizes of Floor Timbers.

Bridging joists (12 inch. centre to centre)
$$D = \sqrt[3]{\frac{L^2}{B}} \times 2.2 \text{ for fir, or } 2.3 \text{ for oak.}$$

Binders (6 feet apart)
$$D = \sqrt[3]{\frac{L^2}{B}} \times 3.42 \quad ,, \quad 3.53 \quad ,,$$
$$B = \frac{L^2}{D^3} \times 40 \quad ,, \quad 44 \quad ,,$$

of timber 2 by $1\frac{1}{2}$ inches, fixed as shown at B, Fig. 266. The advantages of this method of strutting are—(1) that it is not loosened by the shrinkage of the joists; (2) that it acts at the edge of the joist, where its power to resist twisting is greatest. Care should be taken that the struts fit well.

Solid Strutting.—Sometimes the joists are strutted by means of pieces of $1\frac{1}{4}$-inch board, not quite as deep as the joists cut to fit, and nailed between the joists as shown at A. The disadvantage of this system of strutting is the difficulty experienced in making the struts abut properly against any warped sides of the

joists, while any shrinkage in the width of the joist renders it practically useless. This defect is overcome to a great extent by passing a bolt through the centre of the joists immediately to one side of the strutting, and tightening it up with a nut, so that the strutting is tightly cramped between the joists.

Trimming.—When openings for fireplaces, stairs, trap doors occur in floors the joists cannot all be carried on the walls of a building, but are constructed as shown in Figs. 265 and 267, when they are said to be *Trimmed*. When the joists run parallel to the fire-

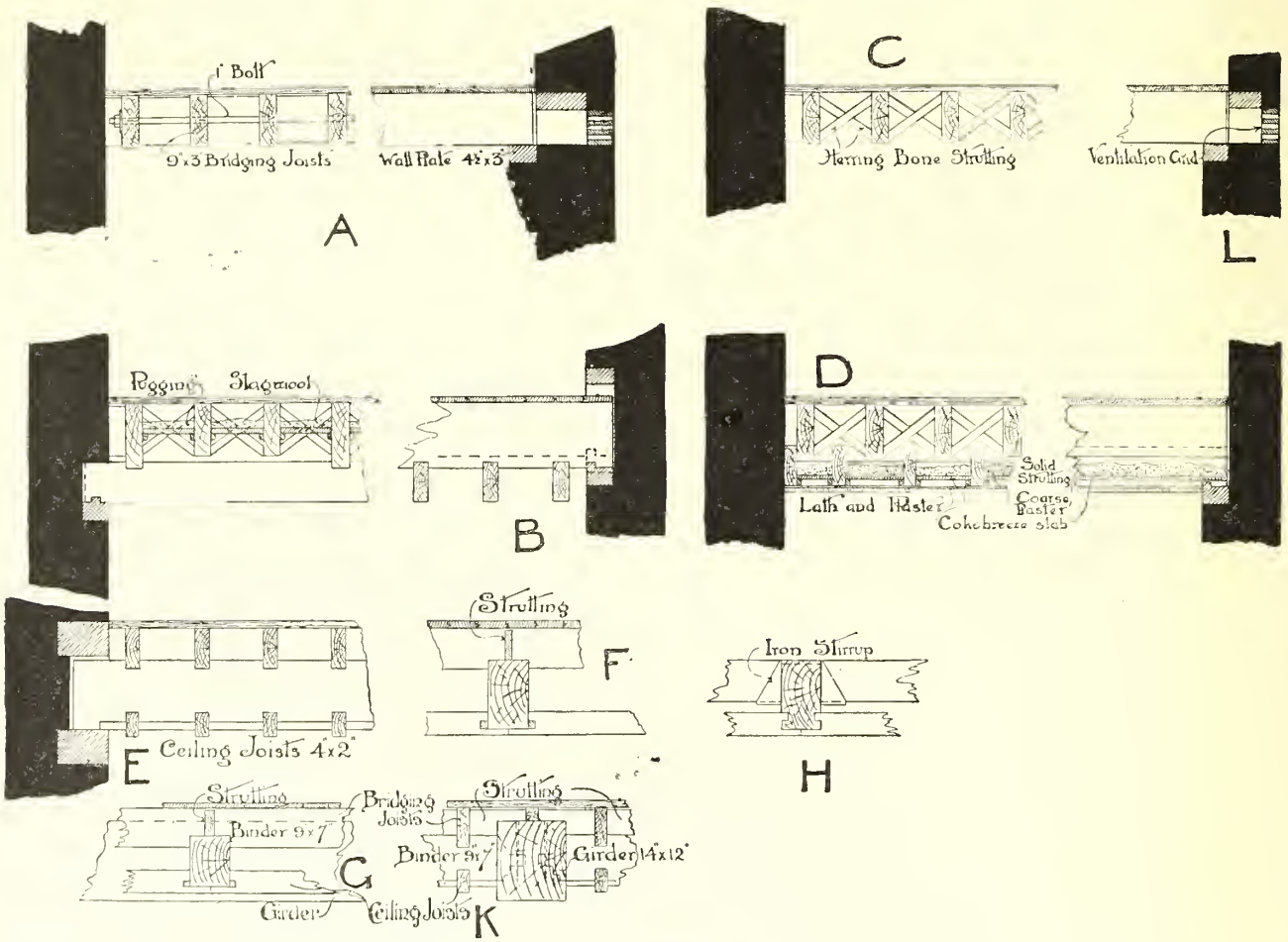


Fig. 266.

place a *Trimming Joist* is carried in front of the chimney breasts, into which *Trimmers* are framed on either side of the fireplace to carry the *trimmed joists*, all as is shown in the right-hand back room in Fig. 265. If a trimmed arch is used in connection with this form of construction two anchor bolts are taken through the trimmer and built into the wall to resist the thrust of the arch.

When the joists run at right angles to the fireplace the trimmed joists are carried on a trimmer, which is framed into two trimming joists on either side of the opening, as shown in Fig. 267.

The proximity of wood to flues is governed in London by the Building Act, which states that no timber or woodwork in any wall shall be placed nearer than 12 inches to the inside of any flue or chimney opening, or within 2 inches from the outer face of any chimney or flue which is less than $8\frac{1}{2}$ inches thick, unless the face is rendered. Woodwork under any chimney opening must not be placed nearer than 10 inches from the upper surface of a hearth.

When joists run into bays, as in Fig. 265, they should either be trimmed into trimmers or rest upon beams or binders placed across the opening, in order to obviate the necessity of increasing the depths to suit the increased span.

The rule for finding the thickness of trimming joists is to make them $\frac{1}{8}$ inch thicker than the common joist for every joist supported by the trimmer, which is itself usually made the same size as the trimming joists.

Bearing of Joists.—The ends of joists of single floors are often built into the walls for a distance of about $4\frac{1}{2}$ inches, but this is not a good method of construction, as these ends are liable to decay and the loads carried by the joists are concentrated on small bearings. Where the joists are built into the walls they should rest

upon $4\frac{1}{2}$ by 3-inch wood wall-plates or on iron bearing bars, so that the load may be distributed throughout the length of the wall. It is by far the best plan to carry the joists on wall-plates supported on iron brackets, or on offsets as at L and D, or on corbels as shown at A in Fig. 266, so that the air may circulate round the ends and so render them less likely to decay.

The joists are joined to the wall-plates, as shown in Fig. 254.

2. Double Floors are used when the span is greater than is convenient for single joints. They consist of bridging joists supported on a second series of beams called *Binders*, as shown in Fig. 265.

Binders, when of wood, should be spaced (says Tredgold) at intervals of from 4 to 6 feet centre to centre, but in practice this higher limit is often exceeded. When the binders are of iron, as is now generally the case, they should be spaced in the most economical manner, this condition being found by experimental calculations. The ends of the binders should not be placed over openings; but where the exigencies of the case make it impossible to do otherwise, strong wall-plates or templates should be used over the openings to throw the weight on to the piers.

The Sizes of Binders are exhibited in the table already given, but it is generally more convenient to bear in mind some simple rule as a guide to proportioning them, such as the following: For binders of 6 feet span use timber 6 by 4 inches; and add 1 inch to the depth and $\frac{1}{2}$ inch to the breadth for every additional 2 feet of span. This will be found to agree exactly with the table.

A formula very frequently used for determining the cantlings of binders is given on page 152, but it will be found to give scantlings somewhat larger than those generally used in practice.

Bearing of Binders.—Binders usually bear about 6 inches at each end in stone or wood templates built into the wall. Pockets are formed round the ends, as shown at E in Fig. 266, so that the air may have a free circulation round them.

The following are approximately the Loads on Floors:—

For ordinary dwelling-houses .	1 cwt. per sq. ft.
For floors of public halls used for concerts and dancing . .	$1\frac{1}{2}$,,
For warehouses . . .	2 to 4 ,,

In the case of warehouse floors, some reasonable estimate of the loads likely to be placed upon them should be made, and the floors calculated to meet the heaviest probable load.

Bridging joists are fixed to the binders by means of any of the joints shown in Fig. 254.

Strutting is frequently introduced above the binders, as shown at F and G, Fig. 266.

When it is undesirable to decrease the strength of binders by notching or housing the bridging joists into them, it is better to suspend the latter from the former by means of iron stirrups, as shown at H, Fig. 266.

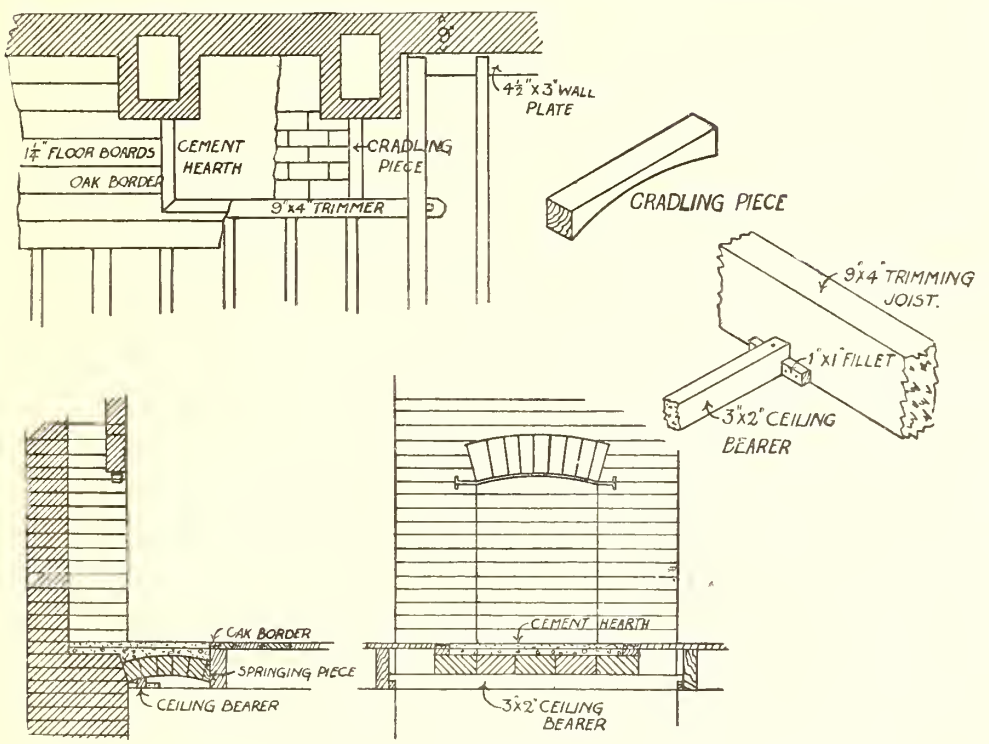


Fig. 267.

3. A Triple-Joisted or Framed Floor, as its name implies, is constructed with three series of joists, namely, —*Bridging Joists*, *Binders*, and *Girders*, as shown in Fig. 268.

Girders are usually spaced at intervals of about 10 feet centre to centre, with their ends bearing from 9 feet to 12 inches on stone templates forming the bottom of a pocket.

The binders are usually tusk tenoned into the girders, as shown at K, Fig. 266.

The Sizes of Girders are exhibited in the table already given, but an easily remembered rule is as follows: For girders of 10 feet span use timbers 9 by 7 inches, and add 1 inch to the depth and $\frac{3}{4}$ inch to the width for every additional 2 feet of span.

Ceiling Joists.—When these are used they are spaced at intervals of from 12 to 15 inches, and are mortised as shown at H, Fig. 266; or, when it is desirable to weaken the binders as little as possible, supported upon fillets, as at F and G. Ceiling joists are made from $2\frac{1}{2}$ to 2 inches wide and $3\frac{1}{2}$ inches deep for a span of 6 feet, $\frac{1}{2}$ inch being added to the depth for every additional foot to the span. They should project beneath the joists to which they are fixed, in order that a proper key may be formed for the plaster ceiling.

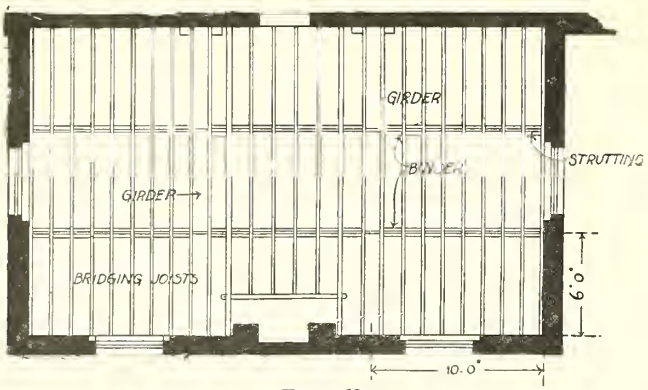


Fig. 268.

Ventilation of Floors.—Floors should be ventilated as thoroughly as possible, to prevent their timbers from decaying. For this purpose ventilating grids are built into the wall, as shown at A and L, Fig. 266, the brickwork above the openings being carried by a stone lintel. It is particularly desirable that the principal timbers in double and triple-joisted floors be ventilated, as serious accidents might happen in the event of their decaying.

Sound-resisting Floors.—With single-joisted floors, where the ceiling is fixed to the under side of the joists, sounds can penetrate from one room to another, and whenever this is undesirable some methods of sound proofing must be resorted to.

Strips of felt or indiarubber laid upon the joists before the floor is laid prevents the penetration of sound to a great extent. And floors with ceiling joists also offer considerable resistance to sound, particularly when they are supported by every third or fourth joist only, as at B, Fig. 266.

Pugging is the name given to the operation of fixing layers of sound-preventing materials between the joists. The most usual method of doing this is shown at B, Fig. 266, where $\frac{3}{4}$-inch boards are fitted between the joists, and rest upon $\frac{3}{4}$-inch fillets, nailed to the sides of the joists and covered with a layer of slag wool or coarse plaster—the slag wool (silicate cotton) being preferable, as it is absolutely dry and will not harbour vermin.

A very efficient sound-resisting floor is shown at D, Fig. 266, in which the ceiling is quite independent of the floor above, the ceiling joists being placed between the floor joists so as not to make the floor deeper than is necessary, while pugging is laid between them.

Double and triple-joisted floors are fairly sound resisting of themselves, owing to the small amount of timber of the whole depth of the floor; but when it is desired to further increase their sound-resisting properties it is only necessary to place felt under the bearings of all the timbers.

Floor Coverings.—The most common form of floor covering is boarding, from 1 to $1\frac{1}{2}$ inch thick, nailed to the joists at right angles to their direction. Boards

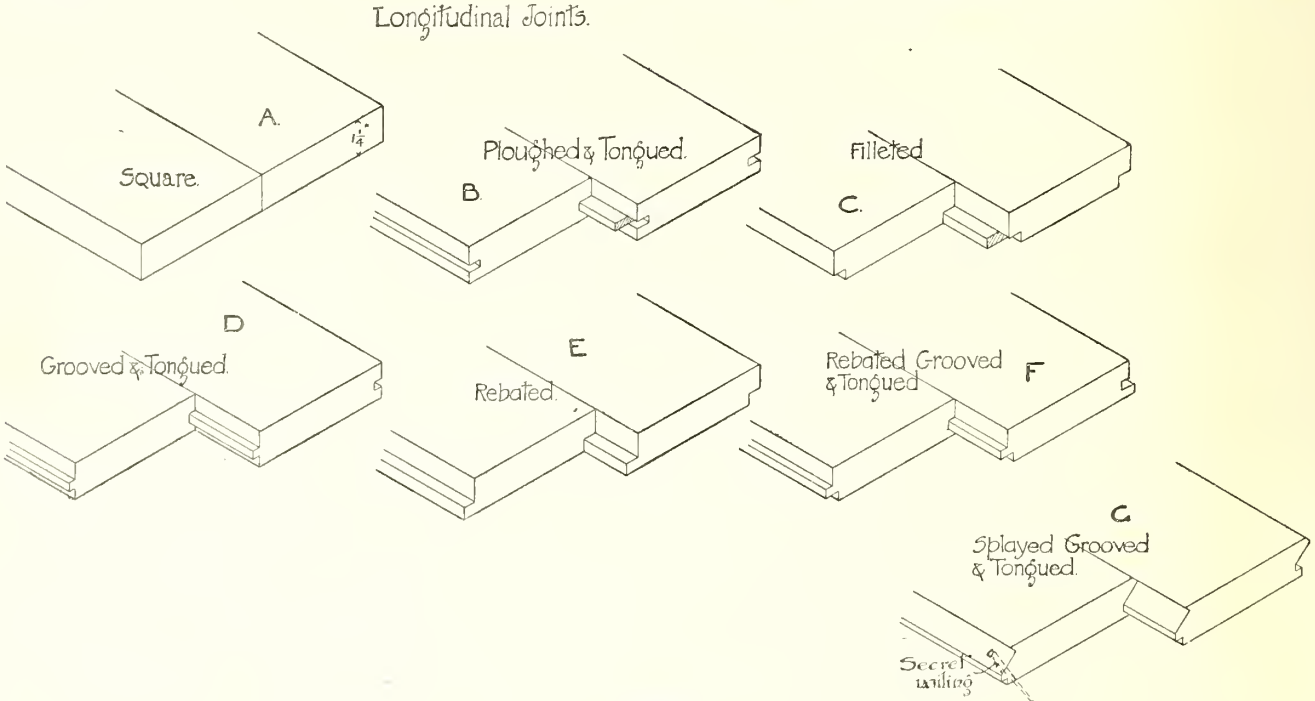


Fig. 269.

of narrow width are best, as the shrinkage which invariably takes place is less appreciable.

Joints in Floor Boards.—The longer edges of floor boards are jointed to one another by any of the joints shown in Fig. 269.

Square or Plain Joint.—The cheapest method of laying a floor is to simply abut the edges and to nail them to the joists, two nails being used for each board at each joist, the boards being first brought tightly together by means of a cramp.

Ploughed and Tongued Joint is a form in which a rectangular section is ploughed out of the edges of every joist rather nearer the lower than the upper surface, and a wood or metal tongue is inserted in the groove, as shown at B, Fig. 269. The object of this joint is to prevent the passage of draughts and dust through the cracks when the floor boards shrink.

Filleted Joint.—A rectangular section, or rebate, is sometimes taken out of the lower edges of the boards, the space being filled when laid by means of a fillet of wood, as shown at C. This is rather less expensive than a ploughed and tongued joint, but the loose fillet is liable to sag or drop between the supporting joists.

A Grooved and Tongued Joint, as shown at D, is a very effective form of dust-proof joint, but it is rather expensive.

A Rebated Joint is formed by taking a rectangular section out of one lower edge and one upper edge of each board, so that they overlap each other when laid as shown at E. It is perhaps the least expensive of dust-resisting joints.

Rebated, Grooved, and Tongued.—It is sometimes found that when the tongue of a grooved and tongued joint is not made very large a small amount of shrinkage will cause a gap sufficiently large to permit the dust to blow through. This defect is remedied by making the joints overlap more, as in the rebated, grooved, and tongued joint shown at F.

Splayed, Grooved, and Tongued Joint.—When it is undesirable to have the floor nails showing, as in a ballroom, a splayed, grooved, and tongued joint, as at G, may be used, a nail or screw being driven through the splay into the joist, and its head covered by the next floor board.

Heading Joints.—The small ends of the floor boards are usually butted together, as at A, Fig. 270; but when it is desired to reduce the number of nails and make a more dust-proof joint, the ends of the boards may be splayed as at B. When a secret fixing is required the dowelled joint shown at C may be used, the nails or screws being driven obliquely through the end of one of the boards into the joist, while the next board is held down by means of hard-wood or metal dowels.

Counter Floors.—When specially smooth floors are required a counter or under floor of ordinary floor boards is laid diagonally across the joists, and upon this an ordinary floor laid.

The upper floor is usually of hard-wood battens, nailed to the counter flooring and brought to a true surface.

Parquet.—Counter floors are sometimes overlaid with small rectangular blocks of various ornamental woods, usually set to some geometric pattern, dowelled or glued to one another and glued to the counter

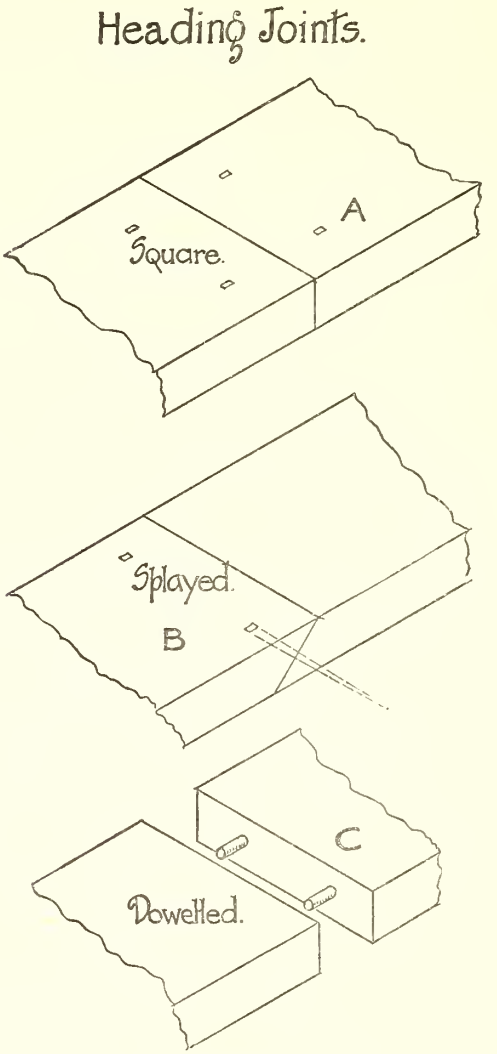


Fig. 270.

floor. When the pattern permits of it, the small blocks are glued up together into larger squares to facilitate fixing.

Wood-Block Floors.—Wood blocks, shaped as shown in Fig. 271, laid in a herring-bone pattern, form an excellent covering to concrete floors. The concrete is covered with a layer of mastic composed of a mixture of pitch and tar well boiled together. The blocks are then pressed into position in the mastic, which oozes up into the V-shaped grooves on their edges, thus forming a key which keeps the blocks firmly in their places.

Fire-resisting Floors.—A good but very costly fire-

resisting floor is formed by placing the joists against one another and spiking them together, as shown

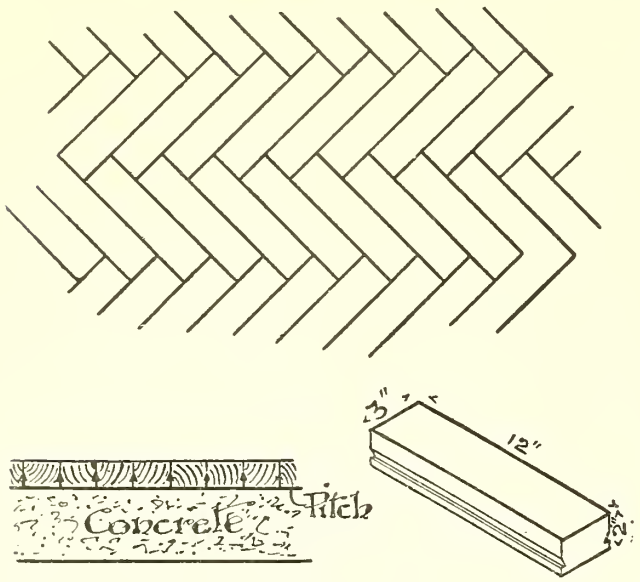


Fig. 271.

in Fig. 272. The joists need not be so deep as in ordinary floors, a rough rule being as follows: The depth of the joists in inches is found by dividing the span in feet by 3 and adding 2. The upper surfaces may be planed to a smooth surface, or floor boards may be fixed in the ordinary way. Fillets are nailed to the under side of the joists to form a fixing for the laths, providing a satisfactory key for the plaster.

Fig. 272A shows Morton's "Valtor" spring floor. This floor is supported upon girders which rest upon cast-iron supports, which in turn are supported upon stout springs. The object of the springs is to impart

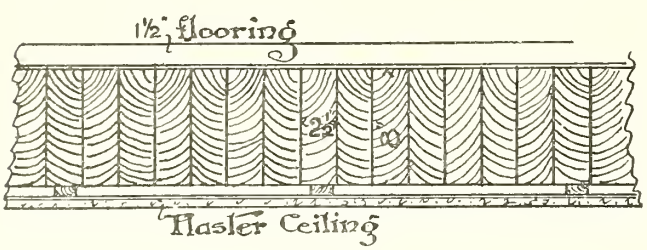


Fig. 272.

elasticity to the floor when it is being danced upon. When the floor is not required for dancing purposes wedges may be driven between the girders and the supports so as to make the floor firm as an ordinary floor.

Fixing Floors.—The best method of laying floor boards is to lay six or more loosely across the joists and cramp them up tightly with a cramp (such as that shown in Fig. 273) when they are nailed. A few more boards are then laid, cramped, and nailed; and so on until the floor is complete.

A method of laying floors sometimes used is that known as "*Laid folding.*" In this method about six boards are placed across the joists with their edges as close as possible; one of the outside boards is nailed and the position of the other outer board is

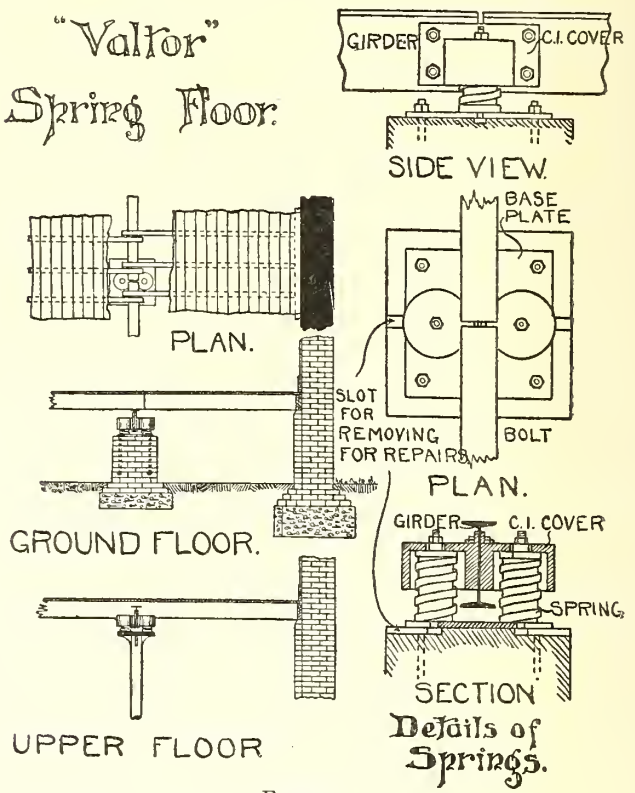


Fig. 272A.

marked upon the joists, the four intermediate boards are taken up and the outer board nailed a little closer to the one first fixed. The intermediate boards are then relaid in the form of an arch between the two outer fixed boards, and a stout board is laid trans-

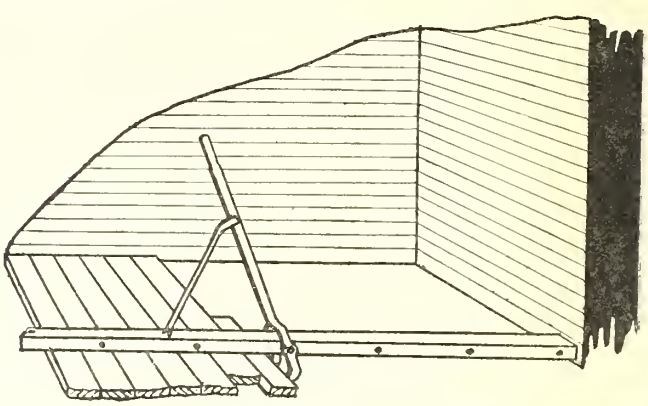


Fig. 273.

versely across them upon which a workman jumps, thus forcing the intermediate boards flat against the joists below in which position they are nailed. A few more boards are treated in the same manner, and the operation repeated until the floor is complete.

CHAPTER XIX

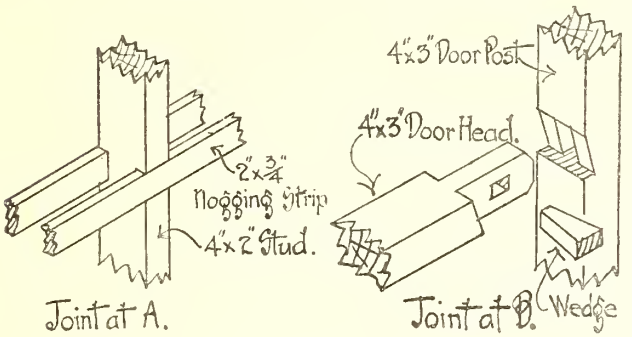
PARTITIONS

THE term "partition" is applied in carpentry to the frameworks of wood, with their coverings of lath and plaster or their filling of brick or concrete, which are used for dividing up floors into rooms, when no solid bearing occurs upon which to erect brick walls, or when brick walls would be unnecessarily strong and expensive.

There are two kinds of timber partitions—

1. Common Partitions.
2. Trussed Partitions.

1. COMMON PARTITIONS.—These are used when the floor to be divided up is amply strong to support their



Common Partition

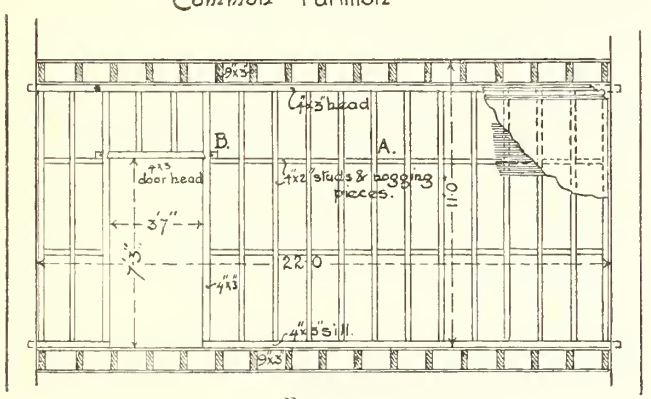


FIG. 274.

weight. They are composed of *Sills*, *Heads*, *Studs*, and *Noggings*, as shown in Fig. 274.

The sills and heads are generally made of 4 by 3-inch or 4 by 4-inch timbers. The studs are of 4 by 2-inch quarters, spaced at intervals of from 12 to 18 inches, according to the strength of the laths, and stub tenoned to the sill and head.

Nogging pieces 4 by 2 inches are cut to fit tightly between the studs, to which they are spiked in a horizontal position at intervals of from 3 to 4 feet. Nogging strips 2 by $\frac{3}{4}$ inch, let into and spiked to the studs in pairs as shown at A, are sometimes used instead of nogging pieces.

The door studs are made 4 by 3 inches or 4 by 4 inches, greater strength being required to resist the slamming of the door, and to form a suitable fixing for the joinery work.

When the partition is at right angles to the floor joists beneath them the sill must be cut clear of the opening, the two parts of the sill being halved and spiked to the feet of the door studs.

Door openings are spanned by a 4 by 3-inch or a 4 by 4-inch head, housed and tenoned to the door studs, as shown at B, Fig. 274.

It should be noticed that all the timbers are of such a size that when framed together they all have a common face.

When a partition is parallel to the floor joists it should if possible rest directly upon one of them, which should be proportioned to bear the additional load. In no case should partitions rest upon the floor boards, as in the event of the floor being taken up for repairs the partition would fall. If a partition necessarily occurs between joists it should be carried on short pieces of timber or bearers framed between them.

The joists of the floor above a common partition should be given ample clearance of the head, so that in the event of the floor sagging no pressure may come upon the partition.

2. TRUSSED PARTITIONS are of two kinds—

(*a*) Self-supporting Partitions.
(*b*) Partitions supporting Floors.

(*a*) SELF-SUPPORTING PARTITIONS.—When the floors to be divided up cannot conveniently be made strong enough to resist the additional load from a common partition, *self-supporting* partitions entirely independent of the floor are erected. As beams, unless made excessively large, deflect under the influence of an ordinary load, and as deflection in the head and sill of a partition would cause the plaster to crack, these self-supporting partitions are *trussed*,—that is to say, the timbers are so disposed and jointed that the vertical loads are diverted to the abutments. In Fig. 275 it will be seen that the pressure upon the head comes partly upon its abutments and partly upon the tops of the posts and braces, whence it is diverted along the braces to the abutments of the sill. The load on the sill is partly

transmitted to the posts from which it is suspended, and these posts in their turn divert the pressure down the braces to the sill abutments. By dividing a framework up in this manner into a series of triangles

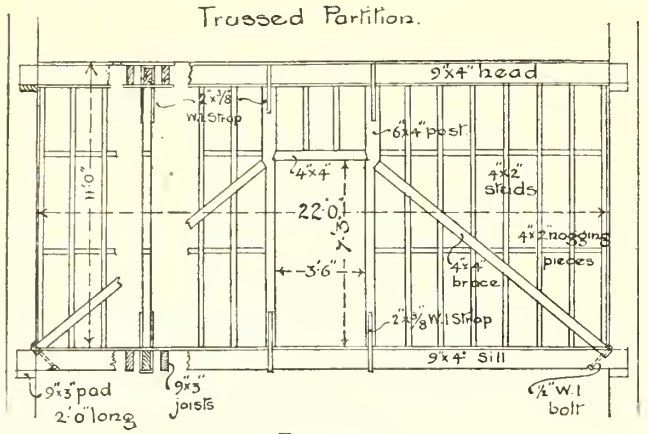


FIG. 275.

it is possible to carry considerable loads across large spans, and a little practice will enable anyone to overcome the difficulty of diverting forces over doors occurring in all sorts of awkward positions.

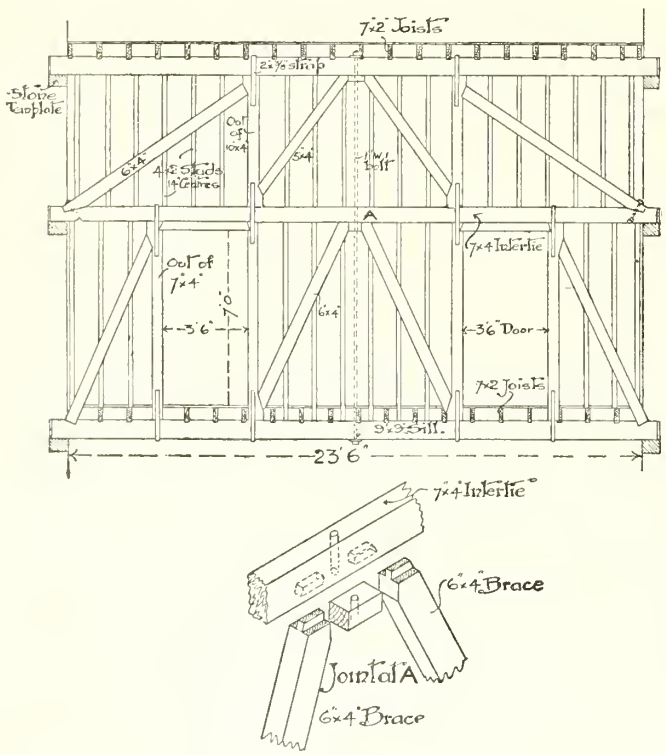


FIG. 276.

In designing trussed frameworks, care should be taken to so dispose the timbers that they may be subjected to either a direct tension or compression and not to a bending stress, otherwise they are very liable to fail.

When the partition is parallel to the floor joists the head and sill should be placed between them, and of course should each be in one piece ; but if it be at right angles to the floor joists the sill must be kept well above them and made in two pieces, so as not to obstruct the door openings.

(*b*) PARTITIONS SUPPORTING FLOORS.—When floors have to be supported on partitions the framing is the same as in self-supporting partitions, save that the timbers must be larger and the braces more numerous to meet the greater load, as shown in Figs. 276 and 277. Horizontal timbers called interties are usually placed above the door openings, so that the loads may be more readily directed past the door openings and distributed more evenly over the supporting walls.

Heads.—In all trussed partitions the head acts as a straining beam for the braces, while it forms a fixing for the posts and studs. In partitions supporting floors

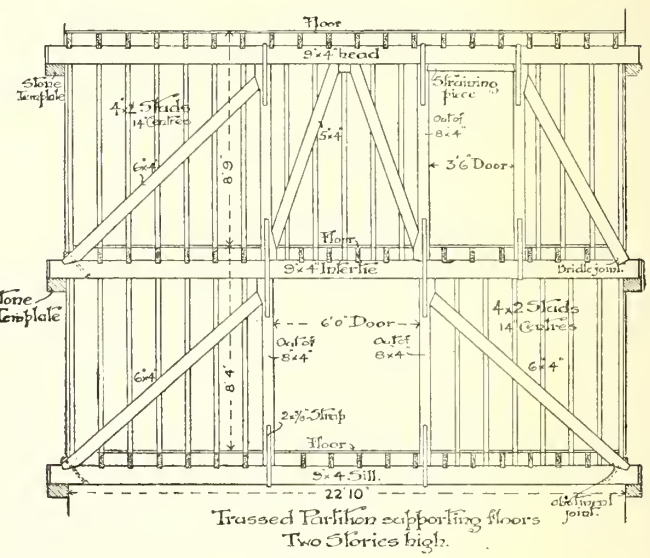


FIG. 277.

the joists are notched or cogged over their heads. The heads should rest at either end upon stone templates bedded in the walls at the bottom of a ventilated pocket, thus distributing the pressure over the wall and preserving the timber from decay.

Interties are used, as already explained, to facilitate the bracing, to distribute the load more thoroughly over the walls, to tie in the feet of the upper series of struts, and, when the partition passes through two floors, to support the joists of the middle floor, as shown in Fig. 277.

Sills are used in all trussed partitions as a fixing for the lower ends of the posts and studs, while they tie in the braces, and in partitions supporting floors they perform the further function of binder to the lower floor joists.

Posts are used as intermediate supports for the head, intertie, and sill, and they should be arranged, as far as the position of the doorways will permit, at regular

intervals along the partition. In no case should the horizontal members of a partition receive support between the external walls save that provided by the posts or braces. When a partition rests at either end upon the main walls of a building it should not receive intermediate support from a cross wall, as the slightest inequality in settlement of the supports would cause unsightly cracks in the plaster.

Shoulders are formed upon the posts for the reception of the ends of the braces.

Posts are stub tenoned and securely strapped with iron straps to the head, intertie, and sill, as they are usually subjected to a tensile stress; for which reason iron bolts are sometimes used in place of posts, as shown in Fig. 276.

Braces.—The function performed by the braces is to transmit the load to the walls.

Braces should be connected to the heads, interties, and sills by means of bridle or abutment joints, as shown in Fig. 277, and to posts by tenoning them into the shoulder. When two struts occur on either side of a tension *rod* they are tenoned into the horizontal member and butted against a straining piece, as at A in Fig. 276.

Braces generally do their work best when inclined at an angle of about 45 degrees, so that in designing partitions the braces should be inclined as nearly at this angle as possible; but should it be necessary to incline a brace very obliquely it should be made stouter than usual, and if long should be strutted at its middle from a post.

Studs.—In trussed partitions the studs are stub tenoned into the heads, interties, and sills, but are simply cut to the required splay and nailed to the braces, as it is undesirable to impair the strength of the latter by cutting mortises in them.

Sizes of Timbers.—It is impossible to lay down any fixed rule for the sizes of timbers in partitions, save that they should be proportioned to the load and to the conditions of the particular case. The following list of sizes, together with the notes appended thereto, will serve as a guide to the selection of timbers of suitable dimensions:—

Heads	.	4 × 7 inches to	4 × 9	inches
Door heads	.	4 × 3 ,,	4 × 4	,,
Interties	.	4 × 7 ,,	4 × 9	,,
Sills	.	4 × 7 ,,	4 × 9	,,
Posts	.	4 × 4 ,,	4 × 6	,,
Braces	.	4 × 4 ,,	4 × 9	,,
Studs	.	4 × 2 ,,		

The above sizes are suitable for spans up to about 20 feet, and may be decreased or increased with the span, bearing in mind the following facts:—(*a*) Heads, interties, and sills need not be increased to any considerable extent as the span increases, as their size depends chiefly upon the spacing of the posts or tension rods, which as a rule are increased in number with the span.

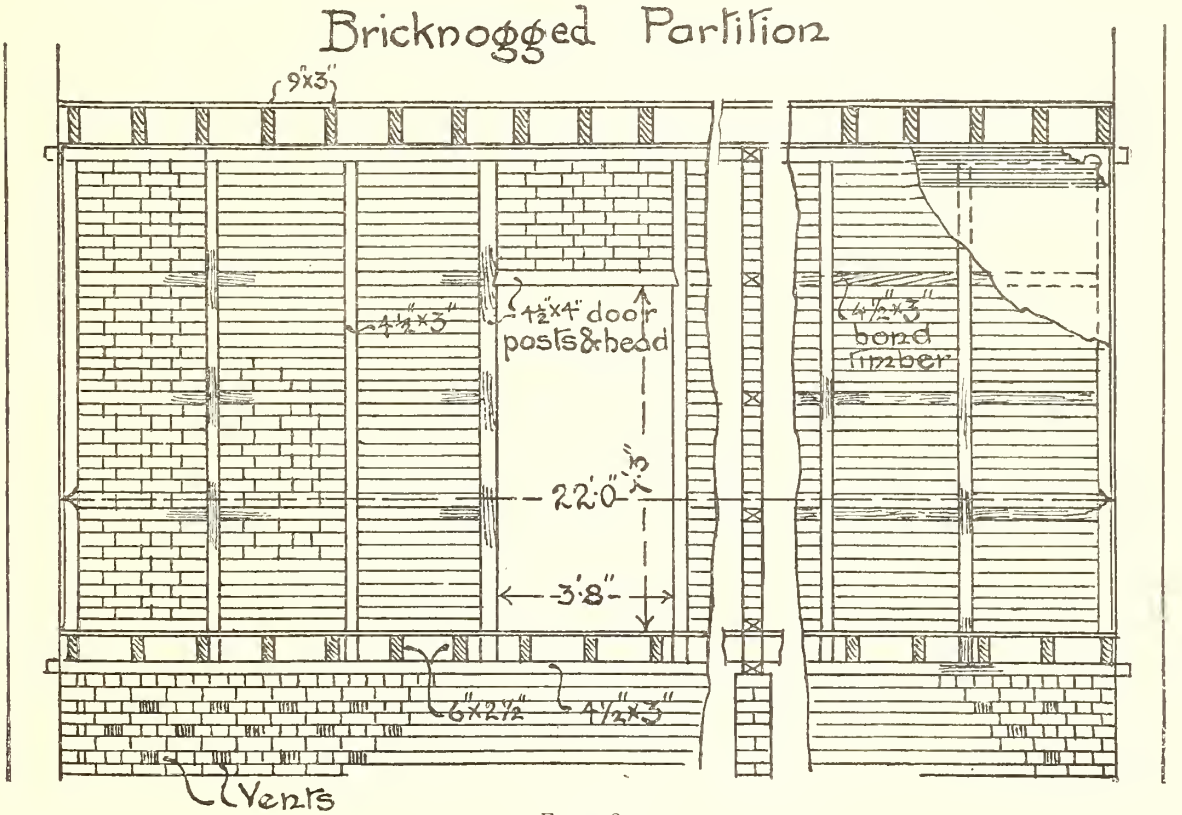


Fig. 278.

Braces increase in size according to their length, and where several braces occur transmitting the loads across successive spans to the abutments, those nearest the abutments are made larger than those nearer the centre of the span, as the former are more heavily loaded than the latter.

As it is desirable to keep the faces of all the timbers in one plane for the convenience of plastering upon them, the studs and door heads vary only in width, and need rarely be increased in depth with the increasing span.

When timbers exceed 3 inches in width on face their edges should be splayed, or wood fillets should be nailed in the direction of their length before the laths are fixed, so as to form a key for the plaster. The plaster should not be applied to partitions until they have been up for some time, so that all settlements may have ceased, and to enable defective joints to be repaired. This is not so essential if the members have been cut for some weeks and stored under cover before fixing. Wire netting or other forms of metal grids are sometimes used in place of laths, over which they possess the advantage of being more rapidly fixed.

Brick and Bricknogged Partitions.—Brickwork $4\frac{1}{2}$ or even 3 inches thick is used for partitioning rooms when a solid support is available along its whole length. Partitions 3 inches thick are formed by laying the bricks on edge.

Thin brick partitions should not be used for walls over 10 feet high, as they are lacking in transverse strength, and bricknogged partitions are used in their place. These consist of 4 by 3-inch quarters, framed similarly to common partitions, but with the studs at intervals of 2 feet 3 inches, 3 feet, or other suitable brick dimension, and with the spaces between the studs filled up with brickwork, as shown in Fig. 278. Fillets of wood from 4 by $\frac{3}{8}$ inch to 4 by $\frac{3}{4}$ inch, called bonding fillets or bond timbers, $4\frac{1}{2}$ by 3 inches, are nailed horizontally between the studs at intervals of from 1 to 2 feet to prevent injury from vibration or shocks. The joints of the brickwork are raked out to form a key for the plaster.

Partitions are sometimes nogged with concrete composed of four parts of coke breeze to one of Portland cement, the sides of the studs having nails driven into them with the heads projecting $1\frac{1}{2}$ inch to form a key for the concrete.

Nogged partitions possess the advantage of being more sound and vermin proof, and more fire-resisting than timber partitions.

Block Partitions.—Numerous forms of partitions are on the market at the present day, made in the

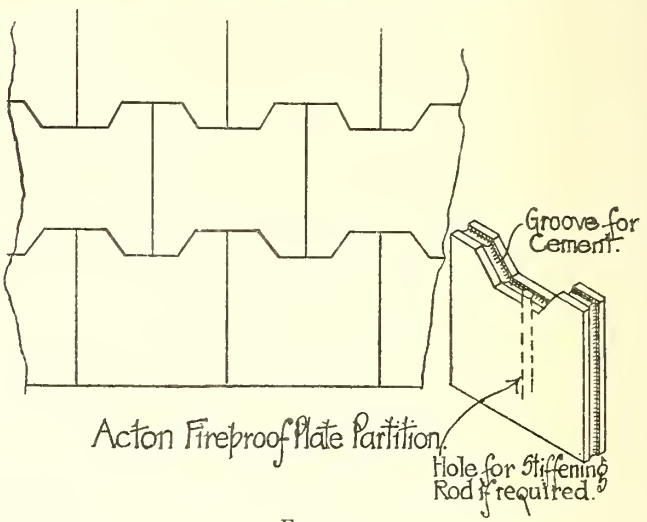


Fig. 279.

form of interlocking slabs of concrete, which can be built up rapidly *in situ*, vertical holes being formed in them for the insertion of bars of iron for giving them greater transverse strength. Some of these, like the "Acton" partition slabs illustrated in Fig. 279, have a rough texture to form a key for a finishing coat of plaster, while others are made with a smooth surface.

Hollow spaces are left within some forms of partition blocks, which may be connected with a room and the outer atmosphere for ventilating purposes.

CHAPTER XX

TIMBER ROOFS

The surfaces of a roof may be inclined at practically any angle, varying from the almost horizontal to the almost vertical. The material with which the roof is covered generally decides this angle, which is known as its pitch.

The following table shows the materials in general

use for roof coverings, and the minimum inclinations as given by Hurst :—

Kind of Covering.	Inclination to the Horizon.	Ratio of Rise to Span.	Weight of Material per Foot super.
			Lbs.
Tin	5° 43′	$\frac{1}{20}$	0.7 to 1.25
Lead	5° 43′	$\frac{1}{20}$	5.0 to 8.0
Zinc	5° 43′	$\frac{1}{20}$	1.0 to 2.0
Copper	7.36	$\frac{1}{15}$	0.8 to 1.25
Asphalted felt	18.26	$\frac{1}{6}$	0.3 to 0.4
Slates, Large	22.0	$\frac{1}{5}$	9.0 to 11.0
,, Ordinary	26.33	$\frac{1}{4}$	5.0 to 9.0
Thin slabs of stone	26.33	$\frac{1}{4}$	20.0 to 25.0
Pantiles	26.33	$\frac{1}{4}$	8.0 to 12.0
Plain tiles	33.40	$\frac{1}{3}$	16.0 to 20.0
Thatch of straw	45.0	$\frac{1}{2}$	6.0 to 8.0

A steeper pitch is required for some materials than others, because they are more liable to strip off under a high wind, and rain is more readily driven in between the joints. In exposed situations the pitch of roofs covered with slate or tile should be steeper than that indicated in the above table. When a roof is steeply pitched, rooms are usually constructed within it, and are lit by means of dormer windows.

Like floors, roofs may be divided into three kinds, according to the arrangement of their timbering, as follows :—

1. Single-Rafter Roofs.
2. Double-Rafter Roofs
3. Triple-Rafter Roofs.

1. Single-Rafter Roofs are such that the roof covering is supported upon a single system of rafters not greater than 15 inches apart. It is only used when the span is small—not greater than 20 feet. Fig. 280 shows several examples of single-rafter roofs.

Lean-to Roofs are formed in a single slope, as shown at A, the upper end of the rafters being spiked to a wall-plate supported on a corbel, and the lower end bird's-mouthed to a wall-plate on a lower wall. This roof should not be used for a span greater than 10 feet, unless the rafters are strutted at their centres from the wall. When a wall occurs conveniently at about the middle of a space to be roofed over, two lean-to roofs may be used, sloping down toward the centre, where a lead gutter is formed. A double lean-to roof is sometimes called a V-roof, on account of the shape of its section.

Couple or Span Roofs are formed as shown at B, the upper ends of the rafters being abutted against and spiked to a *Ridge board*, while the lower ends are bird's-mouthed over and spiked to a wall-plate. This form of roof should not be used for spans greater than 10 feet, unless the walls be very firm, as an outward thrust is exerted by the feet of the rafters.

Couple-Close Roofs are similar to the above, but have the feet of the rafters tied together by means of *Tie beams* spiked to the rafters, as shown at C. The soundest roof is procured by tying the feet of every pair of rafters, and indeed this is necessary when a ceiling is to be attached to the ties ; but when the roof is open a tie is rarely used more frequently than one for every third or fourth pair of rafters. This roof may be employed for spans up to 20 feet. At C, Fig. 280, is shown a roof over a span of 8 feet, but if larger roofs are to be constructed in this way the ridge boards and rafters should be made $\frac{1}{2}$ inch deeper and the ties $\frac{1}{4}$ inch deeper for every additional foot of span, the width remaining the same in all cases.

When the span exceeds 12 feet it is more economical to suspend the ties by means of bolts spaced at intervals of about 6 feet. The ties between the bolts are housed into and spiked to a horizontal timber which is suspended by the bolts, as shown at D. When suspension bolts are used the depth of the ties may be half that found by the above rule.

Collar-Beam Roofs are formed like couple roofs with a beam spiked to the middle of the rafters, as shown at E, where the span is assumed to be 8 feet ; but when larger roofs are required the scantlings may be determined by the same rule as was given for couple-close roofs. This type of roof is employed when a greater amount of head room is required than is given by a couple-close roof, but it is not a sound roof, as it always exerts a thrust upon the walls. The collar, being used to prevent the rafters from sagging, is in a state of compression, and does not tie the rafters together as it is generally supposed to do.

2. Double Rafts or Purlin Roofs are composed of two series of timbers, as shown in Fig. 281, in which it will be seen that the roofs are composed of common rafters supported by means of purlins, for which reason this kind of roof is often called a purlin roof.

These roofs can be used for any span whatever when the gable walls are close together, or when the rafters can be strutted from a floor or central wall.

In Fig. 281 the outline of the roof is that known as a "Mansard," the upper portion being practically a couple-close roof, the rafters resting upon stout outer purlins which are tied together by the ceiling joists, and which are securely spiked between them and the intermediate purlins ; or if greater security is required, the purlins may be tied together by means of one or two $\frac{3}{4}$-inch bolts.

The lower rafters are practically independent of the upper portion of the roof, being merely bearers for the roof boarding of the steeper part, and are secured by spiking them, at the upper end to the purlin, and at the lower end to the wall-plate. The feet of these lower rafters do not need tying, as their inclination to the vertical is so small.

Fig. 282 shows the method of constructing an octagonal trussed roof, and the method of building it

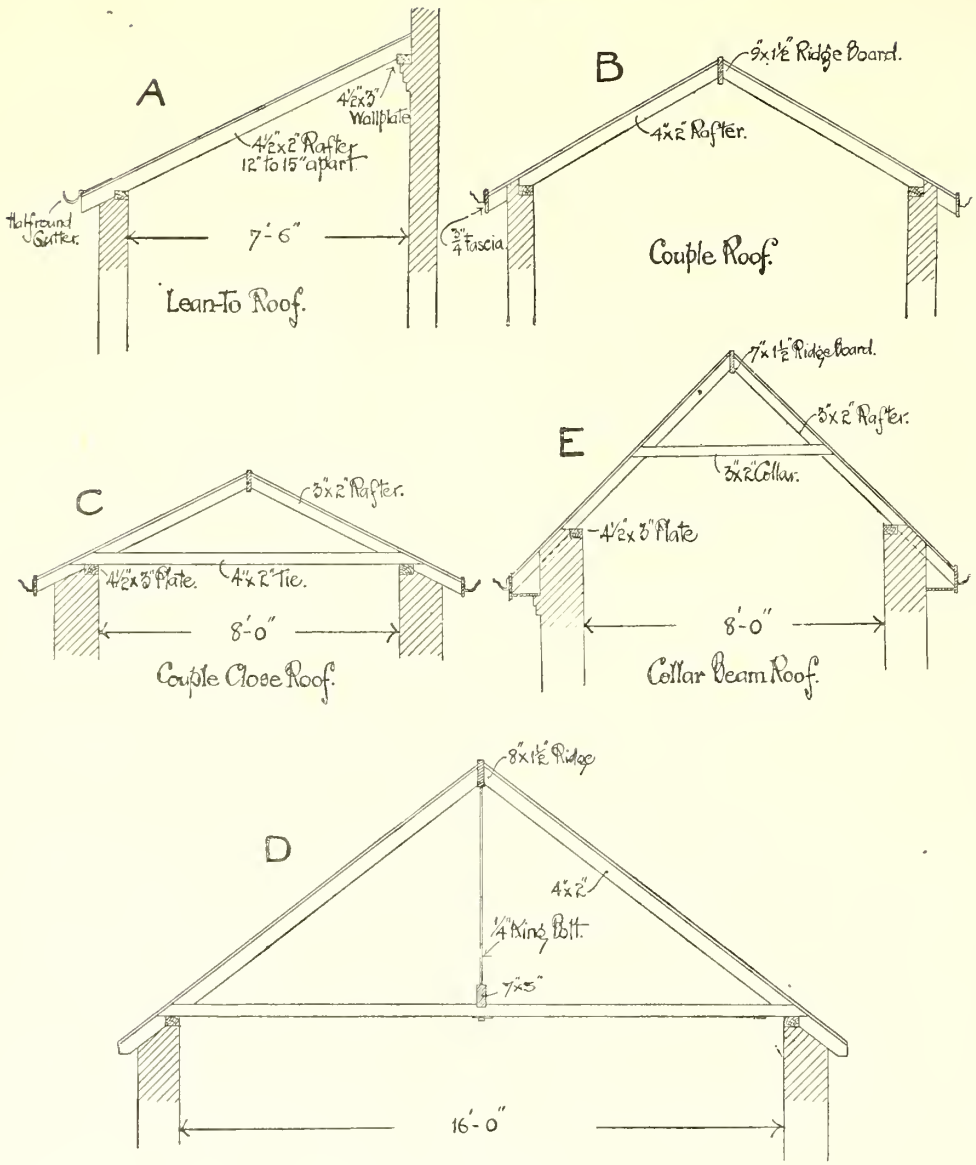


FIG. 280.

is as follows: A wall-plate is laid upon the wall, to which it is anchored by means of iron straps, to prevent it from slipping off when the inclined thrust of the rafters comes upon it. The plates are halved and bolted at the angles, so that they mutually tie one another in, and the bolts for securing the feet of the rafters are inserted before the pieces of wall-plate are laid. The lower ends of two angular rafters are then slipped over the projecting ends of these bolts, and securely nailed to the sixteen-sided block at the apex, which is temporally held in position. The two angular rafters, at right angles to the first two, are then slipped over the bolts at their lower ends and securely nailed to the apex block, and the bolts at the feet of the four rafters are tightened up. The structure thus far completed will be self-supporting. The four remaining angular rafters and the eight rafters resting upon the middles of the sides of the octagon are next fixed.

Pieces of timber are then cut to fit tightly between the rafters, to which they are securely spiked. These act as purlins, and are placed where shown in Fig. 282. The object of the purlins is to stiffen the structure and to provide a means of trimming the rafters, which should not be greater than 15 inches apart, and diminish in number towards the apex of the roof. The short rafters need only be spiked to the purlins.

The surfaces of the roof are then formed with boarding or battens (or both), as in Fig. 282, and may be slate or tile hung, the hips being formed of lead or covered with special tiles.

3. TRIPLE-RAFTER OR TRUSSED-RAFTER ROOFS.—In this kind of roof the covering is supported upon a triple system of rafters, as shown in Fig. 283.

Each rafter in the lowest system forms part of a triangulated framework called a *Truss*. These trusses are usually spaced at distances of about 10 feet centre to centre. The rafters forming part of the trusses are called *Principal Rafters*, and support horizontal timbers called *Purlins* at intervals. Upon the purlins a third system of rafters, called *Common Rafters*, are supported. Trusses consist of Principal Rafters, Struts, Posts, and Ties.

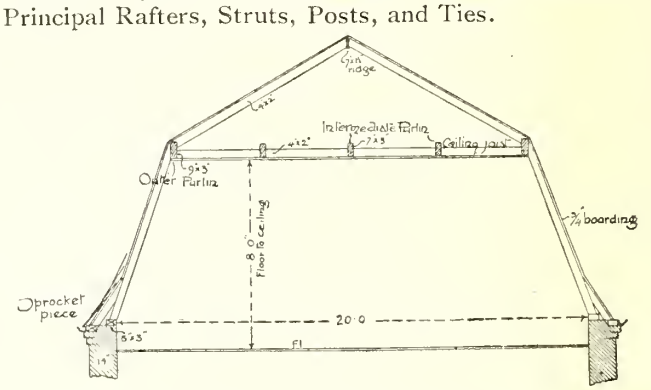


FIG. 281.

Principal Rafters should be supported at regular intervals by means of struts. Their lower ends are

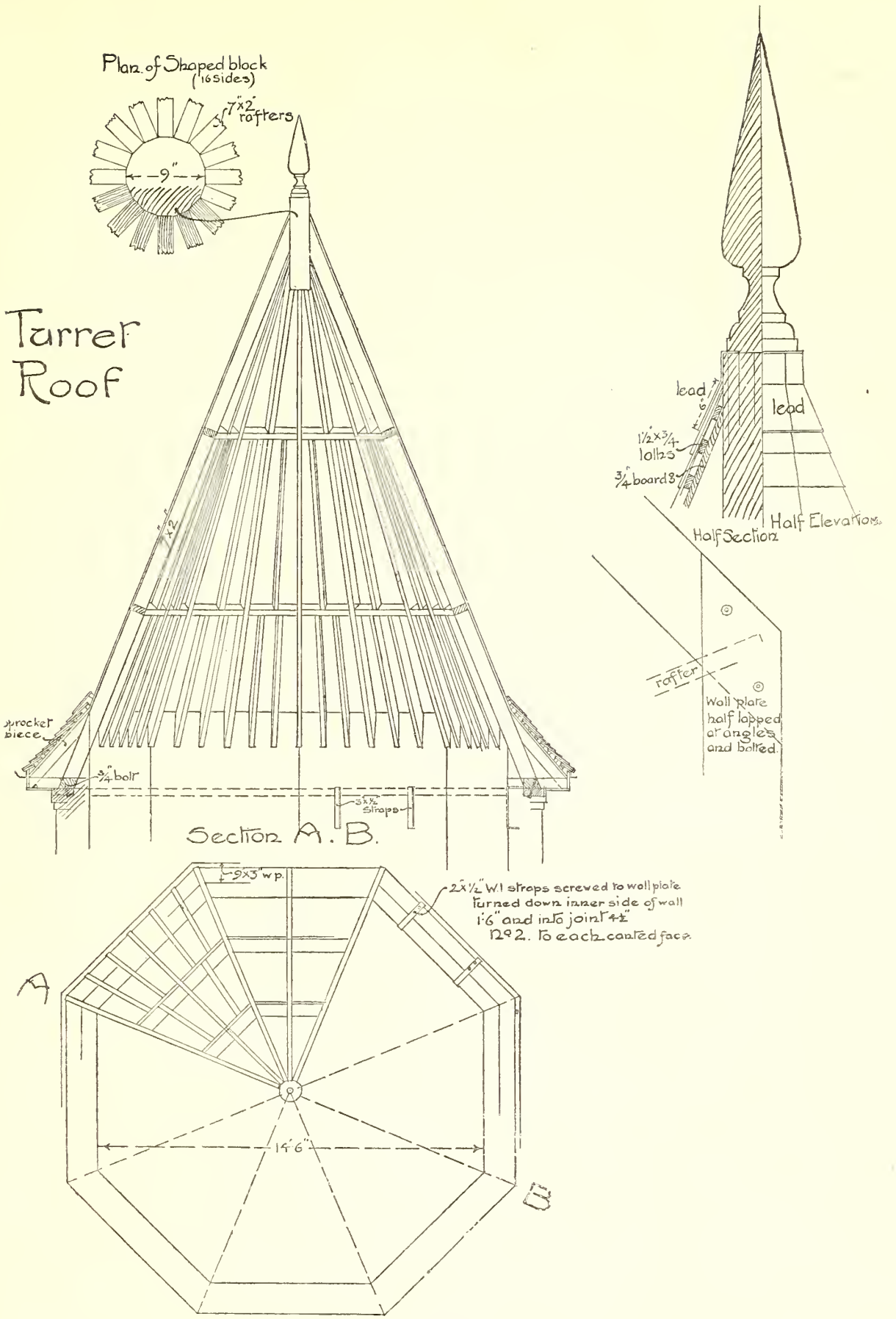

Plan of Shaped block (16 sides)
7"x2" rafters
9"
Turret Roof
lead
lead
1½x¾ battens
¾ boarding
Half Section
Half Elevation
rafter
Wall plate half lapped at angles and bolted.
sprocket piece
¾" bolt
3"x½" straps
Section A. B.
9"x3" w.p.
2½x½" W.I straps screwed to wall plate turned down inner side of wall 1'6" and into joint 4½" No 2. To each canted face
A
B
14'6"

FIG. 285.

connected to the ends of the tie beam by either of the joints shown in Fig. 264, while the upper ends are connected to the heads of the post by means of a housed and tenoned joint.

Struts are employed to support the principal rafters, to which they are connected by means of a tenoned abutment joint. The lower ends of the struts are tenoned to shoulders cut at the bottom of the posts, so that the weight carried by the strut is transmitted to the post. The trusses should be so designed that the struts may be inclined as much as possible to the horizontal.

Posts are formed with sloping shoulders at both ends, against which the principal rafters and struts abut. The lower end of posts are stub tenoned to the tie beams, to prevent them from moving out of place laterally.

Purlins.—The horizontal members which carry the common rafters between the trusses and transmit the load thereto are called purlins, and should be arranged to come directly over the struts. They should be notched or cogged over or housed into the principal rafter. They should never be spaced at greater intervals than 10 feet, otherwise the common rafters will have to be made very large to prevent sagging; but in good work the trusses are so designed that the spacing may not be greater than 8 feet from centre to centre of purlin. When the trusses are farther apart than 10 feet the purlins should be strutted.

To prevent the purlins from tilting, cleats are fixed against the lower face of the purlin.

King Post Truss.—This type of truss is shown in Fig. 283, and may be used up to 30 feet span, if the

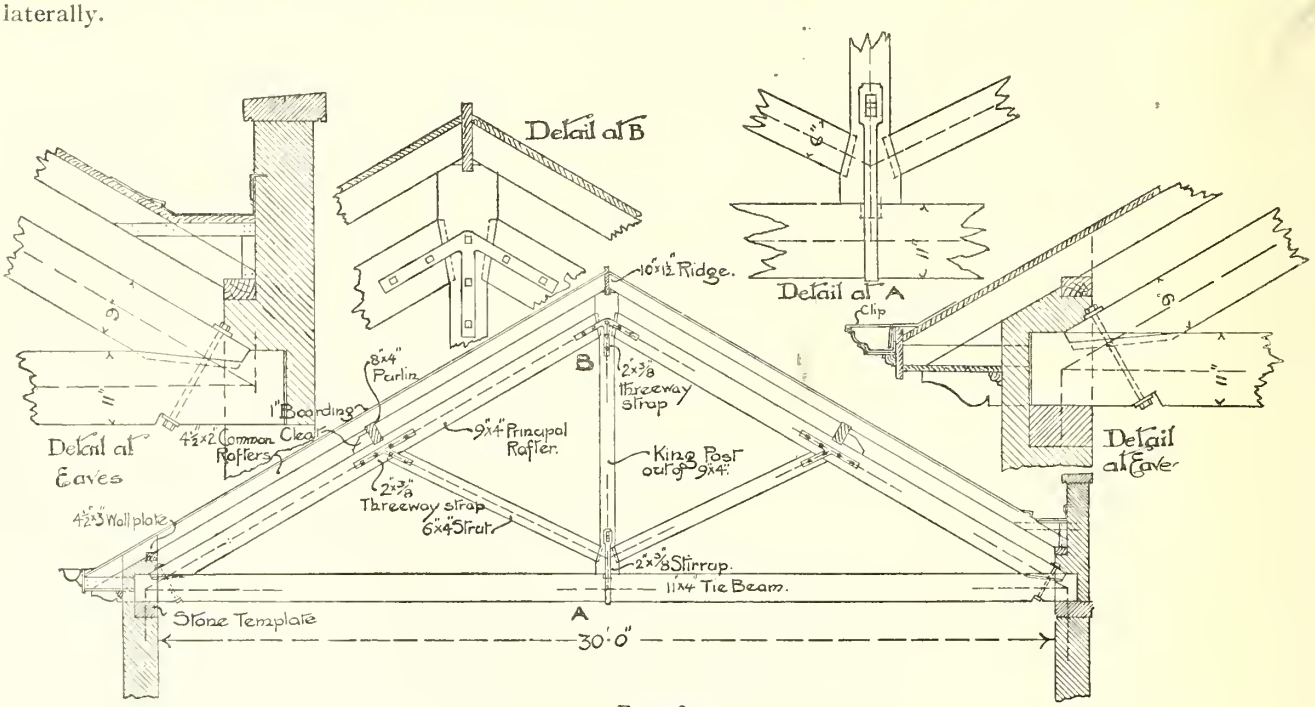


Fig. 283.

Ties are timbers used for connecting the feet of the principal rafters. Their middles are prevented from sagging by connecting them to the posts by means of straps. The ends of tie beams should not be built into the walls, but should be inserted in pockets formed for them, and if possible should be ventilated from the outer atmosphere to render them less likely to decay.

It can be readily seen, in the simpler forms of trusses, that the principal rafters and struts are in a state of compression, while the posts and tie beams are in a state of tension. This is invariably the case with properly designed trusses when not subjected to excessive wind pressures.

Trusses are strongest when designed so that each member is subject to a direct compression or tension. This condition is most nearly fulfilled when the axes of jointed timbers meet at one point.

pitch be not so steep as to make the unsupported lengths of the common rafters too great.

The junction of the timbers at the head of the king post is usually secured by means of three-way straps on either side of the truss, bolted to the timbers. The tie beam is prevented from sagging by means of a strap, which is tightened up with a gib and cotter joint, as shown at A to a large scale. The purlins are placed in such a position that they may divide the common rafters into equal spans, and the slope of the struts is determined by arranging them to come immediately beneath the purlins.

As it is difficult to form a joint in wood suitable for resisting tension a *King rod* is often substituted for a *King post* in this type of truss, as shown in Fig. 284. Where a *King rod* is used a slight variation in construction is needed. Thus a straining piece must be

fixed to the top of the tie beam to give a suitable abutment for the struts, while at the junction of the rafters an iron plate is fixed to prevent them from rising; in which case large cleats have to be fixed to the rafters to support the ridge piece.

When a ceiling is required the tie must be of wood, but where appearance is no object a tie rod of iron is less expensive. In this case a cast-iron socket is used for the upper ends of the principal rafters, having a groove in its head to support the ridge piece, and a hole for the insertion of the ring bolt.

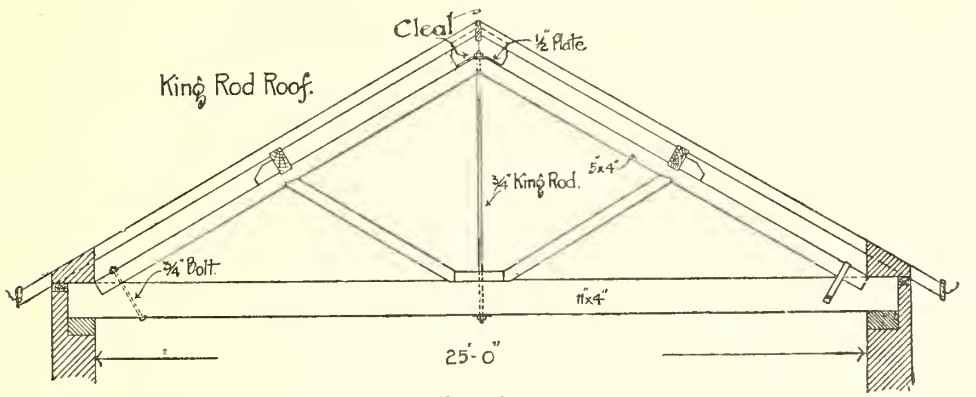


Fig. 284.

The feet of the principal rafters are inserted in cast-iron shoes, which are fixed to stone templates.

Queen Post Truss.—When the span exceeds 30 feet a queen post truss is the most suitable wooden truss. It may be used for spans up to 40 feet. Plate VI. illustrates clearly the construction of this type of roof. It will be noticed that each post receives a thrust both at the head and foot, from one side only, and must be supported upon the other side, for which purpose *Straining Sills* and *Straining Beams* are used.

The purlins are spaced so as to divide the common rafters into three equal parts, and the upper one is supported upon a cleat fixed to the straining beam.

The construction of all the joints are clearly shown in the Plate.

By multiplying the number of posts and struts, roofs may be constructed over very great spans. At one time this was commonly done, but such large roofs are now almost invariably made of iron, and will be therefore considered in a later Volume.

Mansard Roofs.—When it is desired to have a room in the roof it is either necessary to have a very steep pitch to the roof, or to form it as shown in Fig. 285. Such a roof is called a Mansard roof, after its inventor, a French architect of the seventeenth century. It is formed by supporting a king post truss upon a queen post truss, the tie beam of the former forming the straining beam between the queen posts. The advantage of this type of roof lies in the saving of the unnecessary space that would be required for a steep pitched roof giving the same sized room between its rafters.

Hipped Roofs. — The method of constructing a hipped roof is clearly shown in Fig. 286, where a half-truss is fixed at right angles to the last truss of a series, to support the centres of the purlins of the hipped end. The tie of the half-truss is notched over a fillet fixed to the side of the last truss, to which it is secured by a bolt. The principal rafter of the half-truss abuts against the head of the king post of the last truss, and is securely bolted to it as shown in the detail. Stout rafters, called *Hip Rafters*, form the angles of the hips, the upper ends being fixed to the head of the last king post by means of bolts, as shown in detail, and the lower ends tied in by means of a *Dragon Tie*, as shown in Fig. 286.

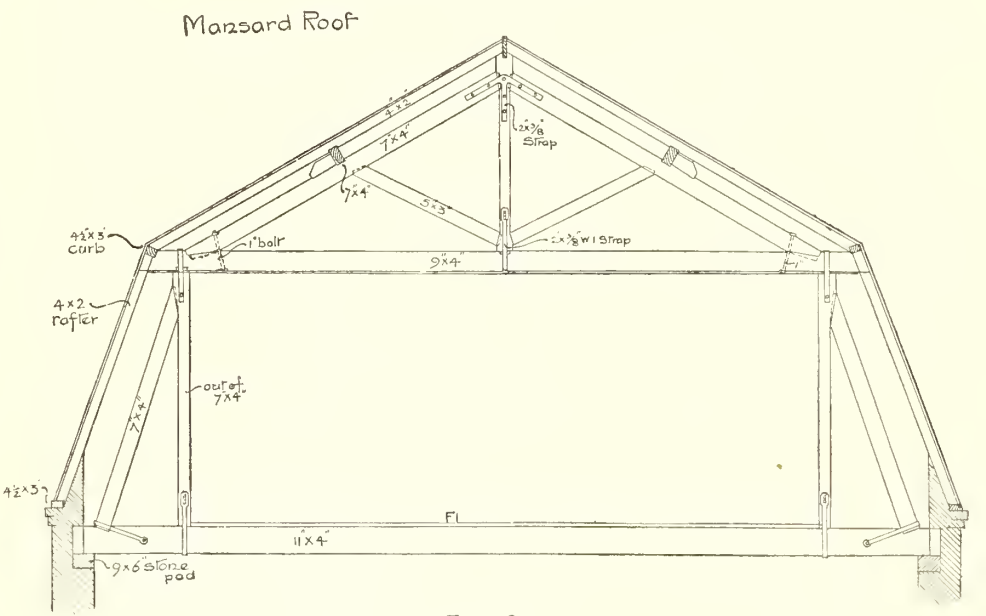


Fig. 285.

Sizes of Timbers. — The following table will serve as a guide when proportioning roof timbers, and may

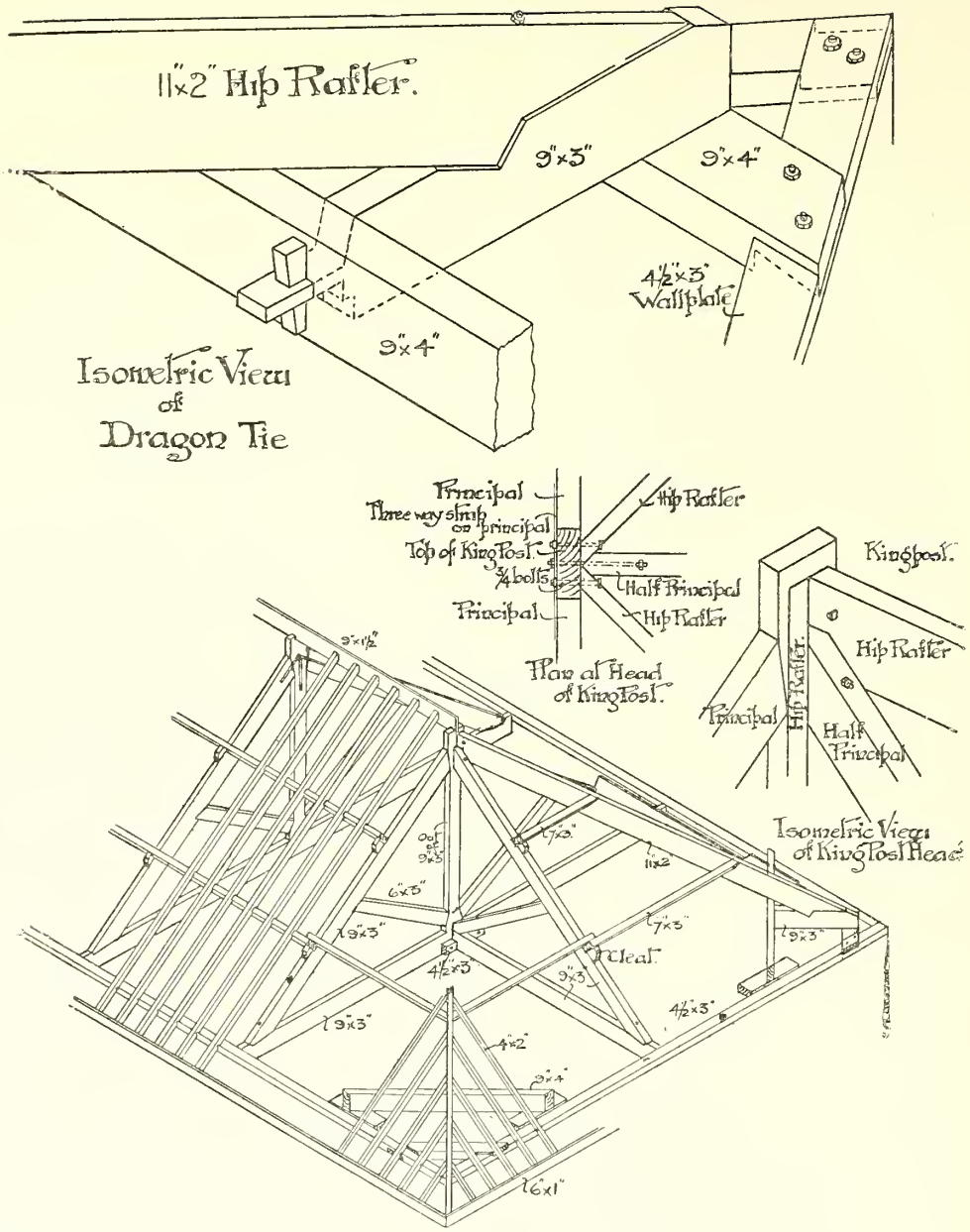


FIG. 286.

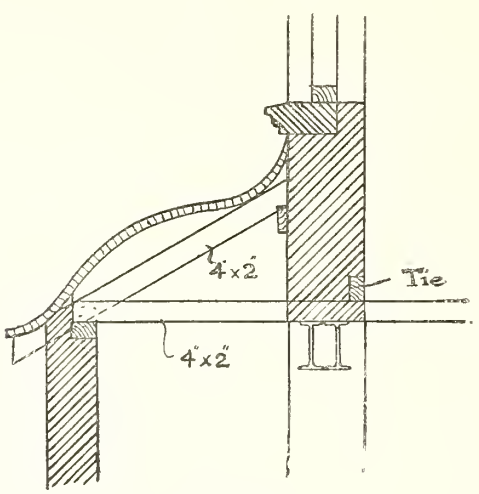


FIG. 287.

be followed absolutely when the roof is hidden; but when an open roof is required the timbers should all be of the same width, so that the faces of all the timbers may be in one plane, as shown in all the illustrations of trussed roofs:—

boarding to exclude the wind and rain, as shown in Figs. 283 to 285.

Roofs with curved Surfaces are formed as shown in Fig. 287, the rafters being either cut away or *firred up* to the required curve. By *firring up* it is meant

HURST'S TABLE OF SCANTLINGS FOR WOOD ROOFS.

Trusses, 10 feet apart; Pitch, 27 degrees; Slate covering; Timber, Baltic fir.

Span in Feet.	Tie Beam.	King Post.	Queen Post.	Small Queens.	Principal Rafters.	Straining Beams.	Braces.	Purlins.	Common Rafters.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
20	$9\frac{1}{2} \times 4$	4×3	...	...	4×4	...	$3\frac{1}{2} \times 2$	$8 \times 4\frac{3}{4}$	$3\frac{1}{2} \times 2$
22	$9\frac{1}{2} \times 5$	5×3	...	...	5×3	...	$3\frac{3}{4} \times 2\frac{1}{4}$	$8\frac{1}{4} \times 5$	$3\frac{3}{4} \times 2$
24	$10\frac{1}{2} \times 5$	$5 \times 3\frac{1}{2}$	...	...	$5 \times 3\frac{1}{2}$	...	$4 \times 2\frac{1}{2}$	$8\frac{1}{2} \times 5$	4×2
26	$11\frac{1}{2} \times 5$	5×4	...	...	$5 \times 4\frac{1}{4}$	...	$4\frac{1}{4} \times 2\frac{1}{2}$	$8\frac{3}{4} \times 5$	$4\frac{1}{4} \times 2$
28	$11\frac{1}{2} \times 6$	6×4	...	...	$6 \times 3\frac{1}{2}$	...	$4\frac{1}{2} \times 2\frac{3}{4}$	$8\frac{3}{4} \times 5\frac{1}{4}$	$4\frac{1}{2} \times 2$
30	12×6	$6 \times 4\frac{1}{2}$	...	...	6×4	...	$4\frac{3}{4} \times 3$	$9 \times 5\frac{1}{2}$	$4\frac{3}{4} \times 2$
32	$10 \times 4\frac{1}{2}$	...	$4\frac{1}{2} \times 4$	...	$5 \times 4\frac{1}{2}$	$6\frac{3}{4} \times 4\frac{1}{2}$	$3\frac{3}{4} \times 2\frac{1}{4}$	$8 \times 4\frac{3}{4}$	$3\frac{1}{2} \times 2$
34	10×5	...	$5 \times 3\frac{1}{2}$	...	5×5	$6\frac{3}{4} \times 5$	$4 \times 2\frac{1}{2}$	$8\frac{1}{4} \times 5$	$3\frac{3}{4} \times 2$
36	$10\frac{1}{2} \times 5$	..	5×4	...	$5 \times 5\frac{3}{4}$	7×5	$4\frac{1}{4} \times 2\frac{1}{2}$	$8\frac{1}{2} \times 5$	4×2
38	10×6	...	$6 \times 3\frac{3}{4}$	...	6×6	$7\frac{1}{4} \times 6$	$4\frac{1}{2} \times 2\frac{1}{2}$	$8\frac{1}{2} \times 5$	4×2
40	11×6	...	6×4	...	6×6	8×6	$4\frac{1}{2} \times 2\frac{1}{2}$	$8\frac{3}{4} \times 5$	$4\frac{1}{4} \times 2$
42	$11\frac{1}{2} \times 6$	...	$6 \times 4\frac{1}{2}$	...	$6\frac{1}{4} \times 6$	$8\frac{1}{4} \times 6$	$4\frac{1}{2} \times 2\frac{3}{4}$	$8\frac{3}{4} \times 5\frac{1}{4}$	$4\frac{1}{2} \times 2$
44	12×6	...	6×5	...	$6\frac{1}{2} \times 6$	$8\frac{1}{2} \times 6$	$4\frac{1}{2} \times 3$	9×5	$4\frac{3}{4} \times 2$
46	$12 \times 6\frac{1}{2}$	...	$6 \times 5\frac{1}{2}$	...	7×6	9×6	$4\frac{3}{4} \times 3$	$9 \times 5\frac{1}{2}$	5×2
48	$11\frac{1}{2} \times 6$	...	$6 \times 5\frac{3}{4}$	$6 \times 2\frac{1}{4}$	$7\frac{1}{2} \times 6$	$8\frac{1}{4} \times 6$	$4\frac{1}{2} \times 2\frac{3}{4}$	$8\frac{1}{2} \times 5$	4×2
50	12×6	...	$6 \times 6\frac{1}{4}$	$6 \times 2\frac{1}{2}$	$8\frac{1}{2} \times 6$	$8\frac{1}{2} \times 6$	$4\frac{1}{2} \times 2\frac{3}{4}$	$8\frac{3}{4} \times 5\frac{1}{4}$	$4\frac{1}{4} \times 2$
52	$12 \times 6\frac{1}{2}$	...	$6 \times 6\frac{3}{4}$	$6 \times 2\frac{3}{4}$	$9\frac{1}{4} \times 6$	$8\frac{3}{4} \times 6$	$4\frac{3}{4} \times 2\frac{3}{4}$	$8\frac{3}{4} \times 5\frac{1}{4}$	$4\frac{1}{4} \times 2$
54	12×7	...	$7 \times 6\frac{1}{4}$	$7 \times 2\frac{1}{4}$	$6\frac{1}{2} \times 7$	9×6	$4\frac{3}{4} \times 2\frac{3}{4}$	$8\frac{3}{4} \times 5\frac{1}{4}$	$4\frac{1}{2} \times 2$
56	12×8	...	$7 \times 6\frac{3}{4}$	$7 \times 2\frac{1}{2}$	$7\frac{1}{2} \times 7$	$9\frac{1}{4} \times 6$	$5 \times 2\frac{3}{4}$	$8\frac{3}{4} \times 5\frac{1}{4}$	$4\frac{1}{2} \times 2$
58	$12 \times 8\frac{1}{2}$	...	$7 \times 7\frac{1}{4}$	$7 \times 2\frac{3}{4}$	$8\frac{1}{4} \times 7$	$9\frac{1}{2} \times 7$	$5 \times 2\frac{3}{4}$	$9 \times 5\frac{1}{4}$	$4\frac{1}{4} \times 2$
60	12×9	...	$7\frac{1}{2} \times 7$	7×3	9×7	10×7	5×3	$9 \times 5\frac{1}{2}$	$4\frac{3}{4} \times 2$

Beam or *Wind Filling* is the name given to the brickwork carried up between the rafters in the roof

that pieces of timber, the same width as the rafters, are cut to the desired curve and spiked to them.

CHAPTER XXI

SLATES AND SLATING

THIN slabs of slate are perhaps the most common form of roof covering. They are cheap, easy to lay, and of good appearance. Slates may be obtained in practically any sizes, those best known being exhibited in the following table :—

Names.	Sizes.	Slates nailed 1 inch from Head. Lap, 3 inches.		Slates nailed near Centre. Lap, 3 ins.		Number per Square.	Weight per Square.	Nails required per Square.	
		Gauge.	Length of Doubling Course.	Gauge.	Length of Doubling Course.			Iron.	Copper.
	Inches.	Inches.	Inches.	Inches.	Inches.		Cwts.	No.	Lbs.
Smalls . . .	12 × 6	4	8	$4\frac{1}{2}$	$7\frac{1}{2}$	530	$6\frac{1}{2}$	1060	$6\frac{1}{2}$
Singles . . .	12 × 8	4	8	$4\frac{1}{2}$	$7\frac{1}{2}$	400	6	800	5
Doubles . . .	13 × 6	$4\frac{1}{2}$	$8\frac{1}{2}$	5	8	480	6	960	6
Ladies . . .	16 × 8	6	10	$6\frac{1}{2}$	$9\frac{1}{2}$	266	$5\frac{1}{2}$	523	$3\frac{1}{2}$
Viscountesses . .	18 × 10	7	11	$7\frac{1}{2}$	$10\frac{1}{2}$	192	$6\frac{1}{2}$	384	$2\frac{3}{4}$
Countesses . .	20 × 10	8	12	$8\frac{1}{2}$	$11\frac{1}{2}$	170	$5\frac{2}{3}$	340	4
Marchionesses . .	22 × 11	9	13	$9\frac{1}{2}$	$12\frac{1}{2}$	138	$5\frac{3}{4}$	276	$3\frac{1}{4}$
Duchesses . .	24 × 12	10	14	$10\frac{1}{2}$	$13\frac{1}{2}$	115	$5\frac{3}{4}$	230	3
Princesses . .	24 × 14	10	14	$10\frac{1}{2}$	$13\frac{1}{2}$	98	$5\frac{2}{3}$	196	3
Empresses . .	26 × 16	11	15	$11\frac{1}{2}$	$14\frac{1}{2}$	79	$6\frac{1}{4}$	158	$3\frac{1}{2}$
Imperials . . .	30 × 24	...	...	$13\frac{1}{2}$	$16\frac{1}{2}$	36	8	72	3
Rags . . .	36 × 24	...	...	$16\frac{1}{2}$	$19\frac{1}{2}$	25	9	50	$3\frac{1}{2}$
Queens . . .	36 × 24	...	...	$16\frac{1}{2}$	$19\frac{1}{2}$	25	9	50	$3\frac{1}{2}$

Slates are also classified as "First," "Seconds," and "Thirds," according to their freedom from flaws and evenness in colour and thickness.

Before the slates can be laid, battens or boards must be fixed to the rafters to form a suitable nail-hold. The least expensive method of slating is to fix the slates to battens, usually about 2 by 1 inch, nailed horizontally across the rafters and spaced at suitable distance, according to the size of the slates.

Battens permit the passage of currents of air, which, if undesirable, may be prevented by the use of close boarding. When rooms are formed in a roof they are frequently unbearably hot in summer and excessively cold in winter, and it becomes essential to construct the roof in such a manner that they may be insulated as much as possible from external heat and cold. The simplest way to do this is to nail close boarding upon the rafters and cover it with sheets of Willesden paper, asphalted felt, or other insulating material. When slates are fixed in this manner the insulating materials are liable to decay, owing to the imperfect ventilation of the intervening space. Proper ventilation may be provided by nailing horizontal battens on top of the insulating sheets. When a roof is in a comparatively inaccessible position, any slates that may happen to get broken are not repaired, and allow the rain water to lodge on top of the horizontal battens, where it causes decay both in the battens and in the insulating sheeting, so that finally the water penetrates to the ceilings below the roof. When ceilings have decorative paintings upon them it is a most important matter to exclude all moisture, and to do this battens are first nailed in the same direction of the rafters, and a second series of battens is nailed horizontally across them.

FIXING SLATES.—When slates are fixed on a roof the following technical terms are used in connection therewith :—

Head.—The upper edge of a slate.

Tail.—The lower edge of a slate.

Lap.—The distance by which the tail of one slate overlaps the head of the slate in next course but one below (see Fig. 288).

Gauge.—The distance apart of the nails which secure the slates to the boards or battens.

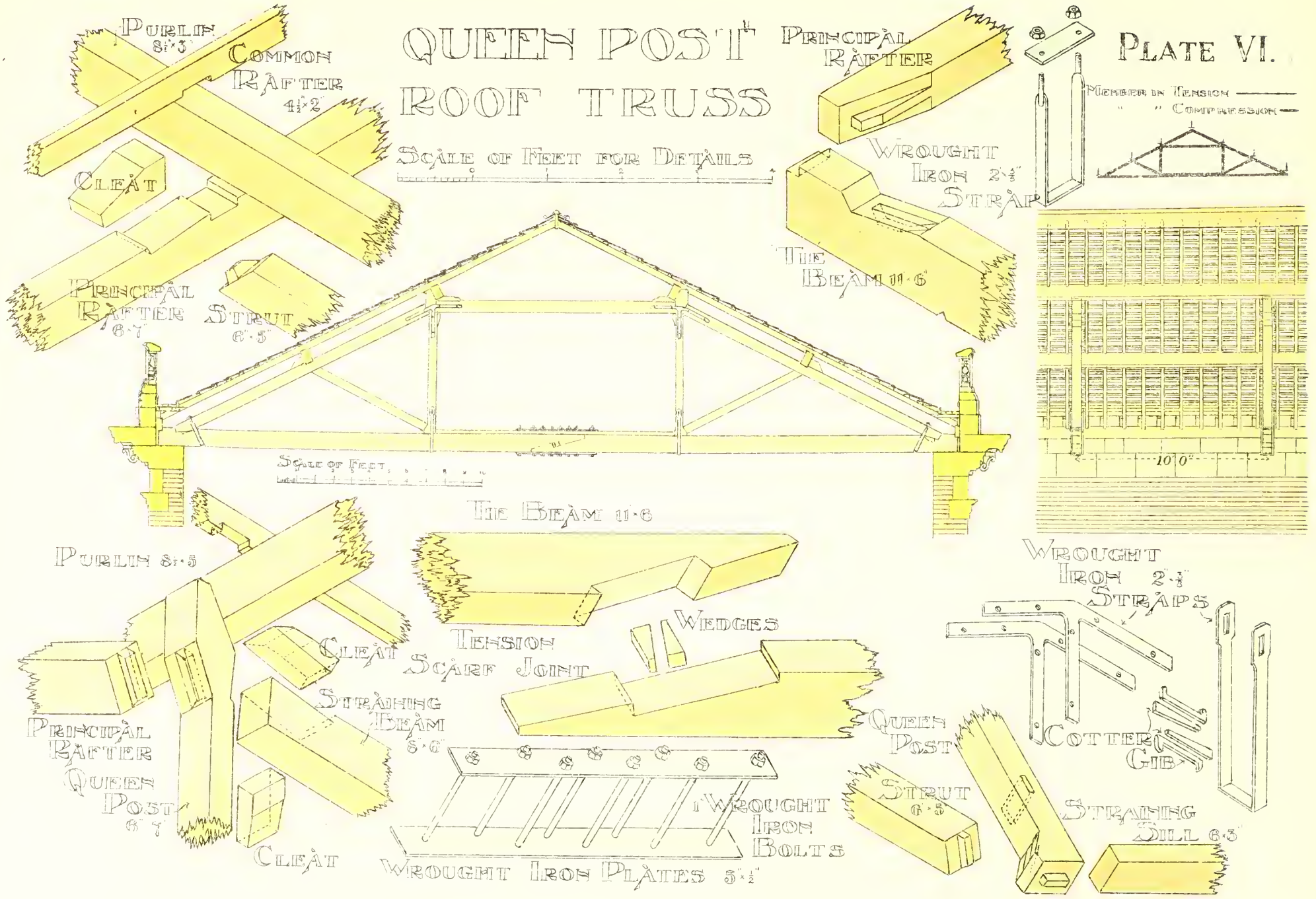
Margin.—That part of each course of slates which is exposed to view.

Back.—The upper surface of a slate.

Bed.—The under surface of a slate.

QUEEN POST ROOF TRUSS

PLATE VI.



Slates are fixed by means of nails, which may be inserted near either the heads or the centres of the slates, two nails being used for each slate.

Slates nailed near the Head.—Before fixing slates the lap must be assumed, and the gauge must always be determined therefrom for the particular size of slate used.

The lap found most convenient in practice varies from $2\frac{1}{2}$ to 4 inches, but a 3-inch lap is most usual.

The following rule is used for determining the gauge of slating:—

$$\text{Gauge} = \frac{\text{Length of slate} - (\text{lap} + 1 \text{ inch})}{2}.$$

The reason for this rule is apparent from Fig. 288,

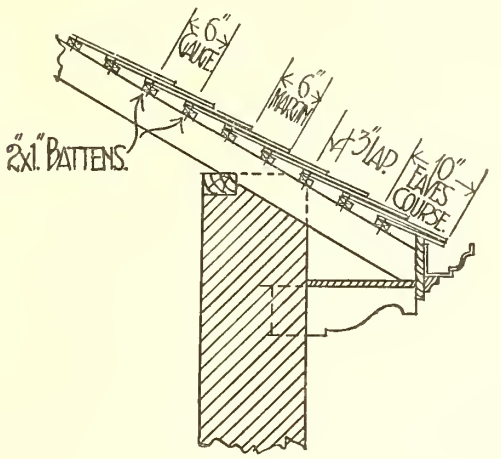


Fig. 288.

where "Ladies" have been used, so that the gauge is $= \frac{16-(3+1)}{2} = 6$ inches. It should be noticed that 1 inch is allowed above the nail-hole, which is not considered in the lap.

The gauge for various sizes of slates laid to a 3-inch lap is given in the Table at the beginning of this Chapter.

When battens are used they must, of course, be spaced centre to centre, to the gauge of the slate.

Slates nailed near the Centre.—In this case the gauge is determined according to the following rule:—

$$\text{Gauge} = \frac{\text{Length of slate} - \text{lap}}{2}.$$

The reason for this rule is apparent from Fig. 289, the margin being equal to the gauge in every case.

The slater usually calculates the position of the holes by adding the lap to the gauge, allowing $\frac{1}{2}$ inch more for irregularities, and measuring from the tail of the slates thus:—

The distance of nail-hole from tail of slate = gauge + lap + $\frac{1}{2}$ inch. The method of nailing slates near the centre is distinctly the better of the two methods of nailing, as it renders the slates less liable to strip in a high wind; while it is a trifle less expensive owing to the allowance of 1 inch over and above the usual lap in the case of slates nailed near the head. It is sometimes urged in favour of the method of nailing near the head that two courses of slates always cover each nail-hole, a statement which seems to infer that this method is more waterproof than the method of nailing near the centre; but no particular degree of leakiness is noticeable with the last-named method. In either method of

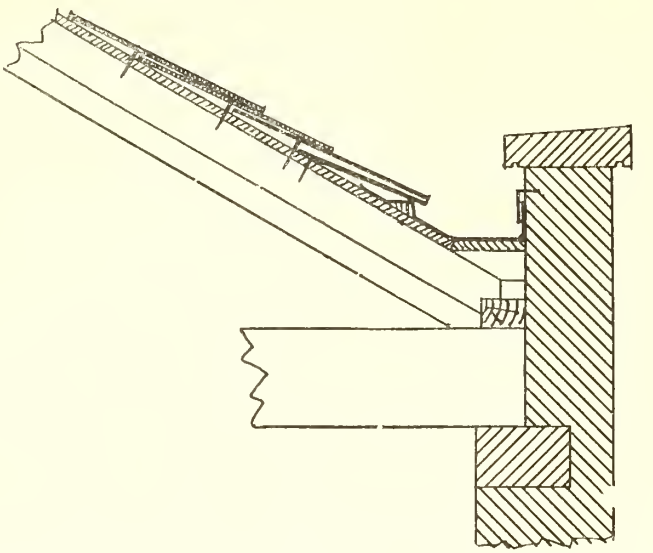


Fig. 289.

nailing the holes should not be farther than $1\frac{1}{4}$ inch from the long side of the slate.

Torching.—When slates are laid on battens only the under sides of the slates are usually torched—that is, pointed with hair mortar composed of three parts of sand to one part of lime, with 9 lbs. of hair thoroughly mixed with every cubic yard.

Close and Open Slating.—It is usual to lay the slates so that the longer edges are close against one another, as in Fig. 290, but in very sheltered situations considerable economy may be effected by spacing the slates in each course from 2 to 3 inches apart, as shown

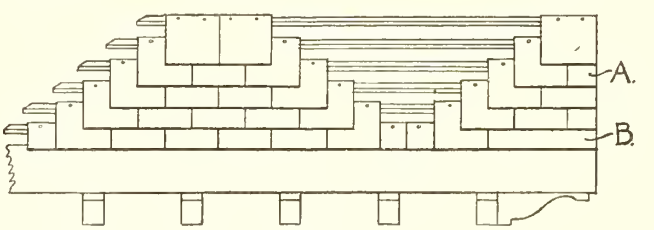


Fig. 290.

in Fig. 291. In this method of slating it is preferable to nail near the centres, so as to render them less likely to strip off in a high wind.

Eaves.—In slating, the work is always commenced at the *eaves* or lowest edge of a roof by laying a row of special cut small slates, called a *Doubling Course*. The length of the slate in this course is determined by adding the lap plus 1 inch to the gauge. Thus in

Fig. 288 the length of the doubling course is 6 + 3 + 1 = 10 inches.

The lower edge of the doubling course is tilted either by means of the facia board, as in Fig. 288, or by means of a *Tilting Fillet*, as in Fig. 289, so as to make its edge fit more closely against that of the next course of slates above.

When battens are used, the lowest one should be placed with its centre at a distance equal to the length of the doubling course minus 2 inches,—1 inch being allowed above the nail-holes and 1 inch for the slates to

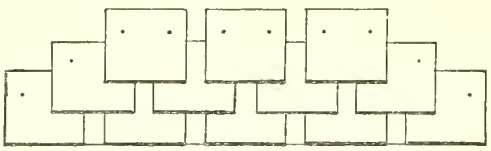


Fig. 291.

overhang the tilting fillet above its lower edge. Thus in Fig. 289 the centre of the first batten is 10 − 2 = 8 inches above the outer edge of the facia board.

Verges.—When a slated roof ends with a verge, or dies against a gable wall, the slates have to be cut to fit. This may be done, as shown at A, Fig. 290, by cutting slates of the size used for the rest of the roof, or, as at B in the same Figure, by cutting larger sized slates. The latter method, needless to say, is preferable.

The under side of verges should be pointed.

When a slate roof dies against a gable wall a cement fillet is sometimes formed at the junction to keep out the rain, but lead flashings, as described in a later Chapter, make a more watertight joint.

Ridges and Hips.—The slates have to be cut to fit at the ridge and hips of a roof, and the angles between the different planes of the roof are covered either by

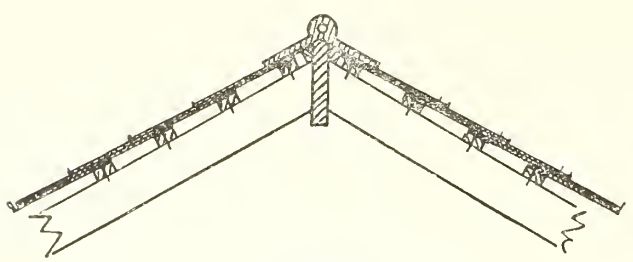


Fig. 292.

means of a slate ridge piece, as shown in Fig. 292, or by means of tiles made for this purpose, thoroughly bedded in hair mortar. Slate ridge pieces are often made in two pieces, one of which is holed and screwed to the ridge board by means of copper screws, the holes being stuffed with white lead, while the other fits over the first.

The junctions of hips and ridges are usually covered by means of a specially made tile, and when a ridge terminates in a verge special finial tiles are frequently used.

Lead is also used for making ridges and hips watertight.

Repairing Slates.—When slates become broken they are removed, the nails being cut away or drawn by means of a ripper—an iron instrument about 2 feet long, with a handle at one end and a thin blade terminating in a broad end, of the shape shown in

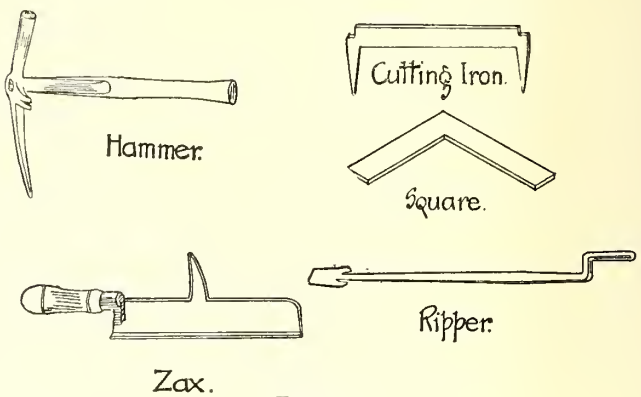


Fig. 293.

Fig. 293. The indentations in the edge of the broad end are for catching the shank of the nail to be cut.

Strips of lead or copper, called *Tacks*, are now hooked over the head of the slate beneath the space to be repaired, and a new slate is slipped into position, where it is kept by turning the lower ends of the tacks over the tail of the new slate, two tacks being used for each slate.

Stone Slab Roof Covering.—Stones that can be split into slabs of from ½ to 1 inch in thickness are also used for roof coverings. Such stones come from the limestone quarries of Colly Weston, Northamptonshire; Stonefield, Oxfordshire, and Naunton, Gloucestershire. These stones are supplied in odd sizes up to about 2 feet square, and must be sorted before use, the longer slabs being used at the eaves. The courses should diminish in size towards the ridge, the battens upon which they are laid being fixed to the diminishing gauge. Laths are nailed to the rafters between the battens, and the

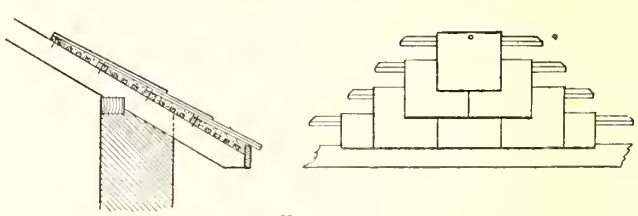


Fig. 294.

space between the battens filled up with stone lime mortar, preferably made from the same limestone as the slabs (see Fig. 294). The slabs are then laid, commencing from the eaves as in ordinary slating, one nail being inserted at the head of each slab, which should be thoroughly bedded in lime mortar. The joints of the slabs are pointed in lime mortar as the work proceeds.

Nails.—The nails for securing slates to the boards or battens have flat circular heads large enough to overlap the holes, and are made of iron, copper, zinc, composition, or lead.

Iron nails are made of either cast or malleable iron. Cast-iron nails resist oxidation well, but are brittle and snap easily. Malleable iron nails are usually galvanised or painted to resist oxidation.

Copper nails resist oxidation well, are expensive, and are therefore not used to any great extent.

Zinc nails are very soft, and consequently difficult to drive.

Composition nails, made of an alloy of tin, copper, and zinc, are hard enough to permit proper driving and resist oxidation.

Long lead nails are used chiefly with iron battens, being placed through the holes in the slates and bent round the battens.

Tools.—The edges of slates are trimmed by means of a tool called a *zax*, Fig. 293; the slate being laid over an iron *straight edge* or *cutting iron*, which is fixed to the edge of a bench. The slate to be cut is laid across the cutting iron and a few smart blows with the sharp edge of the zax cuts the slate to a straight edge. A sharp point is formed on the back of the zax for holing. A metal square is used for testing the squareness of the slates. The nails for slates are driven by means of a *Slater's Hammer*, which is provided with a sharp point at one end for holing, while at the side is a claw for removing broken or bent nails.

Fig. 293 also shows a *Ripper*, which is used, as already explained, for repairing work.

CHAPTER XXII

TILES AND TILING

Tiles for roofing purposes consist of thin plates of vitrified clay, and are made in an infinite variety of shapes and sizes. They are usually of a red colour, but can be obtained in practically any shade. The tiles in general use are exhibited in the following table:—

Name.	Sizes in Inches.	Weight of each Tile.	Tiles required per Square.	Gauge.	Weight per Square.
		Lbs.	No.	Ins.	Cwts.
Plain Tiles	$10\frac{1}{2} \times 6\frac{1}{2} \times \frac{1}{2}$	$2\frac{1}{2}$	800	3	15
	$11 \times 7 \times \frac{5}{8}$	3	700	$3\frac{1}{2}$	
			600	4	
Pantiles	$13\frac{1}{2} \times 9\frac{1}{2} \times \frac{1}{2}$	$5\frac{1}{4}$	180	10	8
			164	11	
			150	12	

Plain tiles are made with a slight curve throughout their length, to cause their tails to fit closely against course below, and have small projections called "nibs" at the back for hanging them on to the laths, or holes at the head for nailing, or both.

Pantiles are much used for shed roofs, and are curved as shown in Fig. 295.

Fixing Tiles.—Plain tiles are fixed to battens or boards or both, arranged as described for slates in the previous Chapter.

The laths used for plain tiles are either of fir ($1\frac{1}{4}$ by $\frac{3}{4}$ inch to 2 by 1 inch) or oak ($1\frac{1}{4}$ by $\frac{1}{4}$ inch), and are made in 5 feet lengths, one *bundle* of 100 fixed to the rafters with 150 lath nails being required per square of tiling.

The lap used for tiles varies from 3 to 4 inches, according to the size of the tile, the pitch of the roof, and the climate of the locality in which they are used.

The gauge is determined thus—

$$\text{Gauge} = \frac{\text{Length of tile} - \text{lap}}{2}.$$

In Fig. 296, $10\frac{1}{2}$ by $6\frac{1}{2}$-inch plain tiles are used, and laid to a $3\frac{1}{2}$-inch lap, so that the gauge $= \frac{10\frac{1}{2} - 3\frac{1}{2}}{2}$ in. $= 3\frac{1}{2}$ inches.

When tiles with nibs are used they are only nailed every three or four courses on roofs of steep pitch, while when on roofs of flat pitch every tenth course only need be nailed.

Pegs of cast iron or oak are also used for fixing tiles, they being wedged into the nail-holes and hung upon the laths.

Pantiles are laid upon laths with a good bed of hair mortar to keep them in their place. The laths for pantiles are 10 feet long, a "bundle" of 12, secured to the rafters by means of 125 lath nails, being required per square (100 feet super.) of tiling.

Glass tiles of the same shape and size as pantiles are often used for skylights.

Eaves.—The tiling is commenced from the eaves, which are treated in a similar manner to slate eaves,

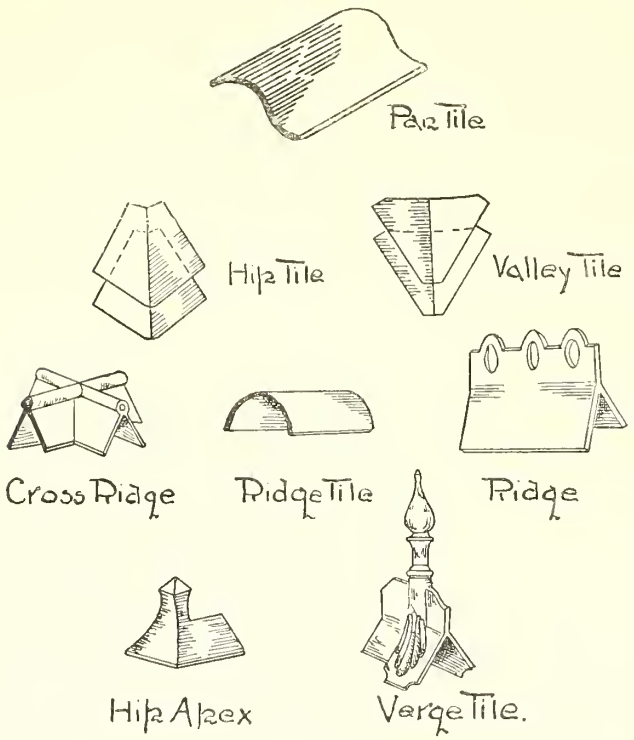


Fig. 295.

special short tiles being made for the doubling course of the same width as the ordinary tiles, and of a length equal to the sum of the lap and the margin, as shown in Fig. 296. The doubling course should be firmly nailed to a board splayed so as to cause the tail to fit closely against the tail of the course above. The tail of the lower two courses should overhang the gutter, so that rain water may drip clear of the woodwork. The first batten is fixed at a distance above the lower edge of the board upon which the doubling course is fixed, of the length of a tile less the distance of the nail-holes from the head of the tile, and less the amount of overhang.

Verges.—When a roof terminates as a verge or against a gable, specially made "half" tiles, as at A, Fig. 296, or "tile-and-a-half" tiles, as at B, should be used. The brickwork beneath the verge should be cut to the slope of the roof, and the tiles should be soaked and bedded in Portland cement so as to tilt away from the edge, thus throwing the water on to the body of the roof and preventing the verge from dripping.

When the roof abuts against a gable wall the wet is excluded by means of "lead soakers" or "secret gutters."

Ridges.—Specially made short tiles are made for the uppermost courses of tiles, the length being equal to the length of a tile minus the margin plus 1 inch for the nail-hole, as shown in Fig. 296.

To obviate the necessity of cutting the tiles at the ridge the following simple calculation is made: The lowermost and uppermost battens having been fixed in position, measure the exact distance from centre to centre of these and divide by the gauge. Thus suppose the distance from centre to centre of the two extreme battens is 27 feet $6\frac{3}{4}$ inches, which, divided by the gauge $3\frac{1}{2}$ inches = 95 and $2\frac{1}{2}$ over. If the battens are nailed on starting at the bottom, and working upwards are spaced at intervals of $3\frac{1}{2}$ inches, there will be a gap between the two top battens of $2\frac{1}{2}$ inches, which would necessitate the cutting of an inch off the top tile to keep the margin uniform; but to obviate this, all that need be done is to space the battens a little farther apart. It is clear that the gauge is practically unaltered if $2\frac{1}{2}$ inches is spread out between 94 battens.

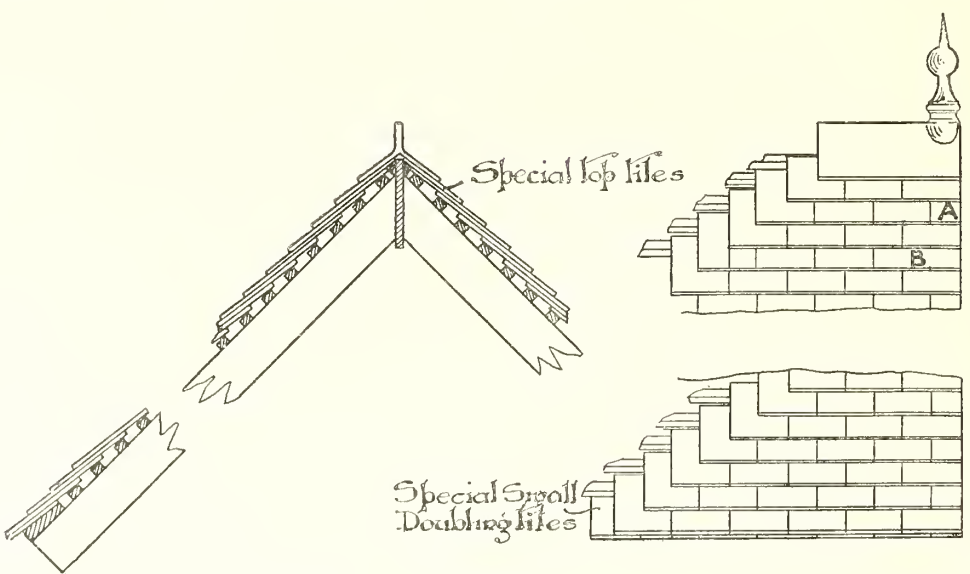


Fig. 296.

Specially made tiles are used for covering ridges, as shown in Fig. 295, and are usually bedded in hair mortar. It is a good plan to bed only the ends of such ridge piece, as this permits the air to circulate beneath, and thus prevents the ridge board from rotting.

Purpose made ridge finials are made for covering the apices of verges and the junctions of ridges, as shown in Fig. 295.

The vertical joints of ridge pieces should be pointed.

Hips.—In cheap work the edges of the tiles are roughly cut to fit the hips, and the junction is covered with a half-round tile bedded in hair mortar. It is better, however, to use purpose made hip tiles, as shown in Fig. 295.

Valleys.—The most usual way of treating valleys is to stop the tiling of the adjoining roof somewhat short of the valley and to form a lead gutter. Sometimes purpose made narrow tiles are worked round the valley, or purpose made nailing tiles are used, as shown in Fig. 295.

Pointing Tiles.—The joints of tiles are sometimes pointed as a further safeguard against the passage of wet and wind, and in good work pulverised tiles are often substituted for sand in the pointing mortar, so that its colour may be as nearly as possible that of the tiles.

Vertical or Weather Tiling.—Walls are sometimes covered with vertical tiling, for the purpose of throwing off the rain and of maintaining a more equable temperature within the building, the air space beneath the tiles acting as an insulator. If tiles are nailed to the joints of brickwork the gauge is only about 3 inches, which gives a lap of $4\frac{1}{2}$ inches. This makes the work unnecessarily extravagant in tiles. For this reason they are usually fixed to battens or fixing blocks, or else the wall is built with wide joists, as shown at A, Fig. 297, and the tiles are nailed to the joints, the gauge being about 4 inches, which gives a lap of $2\frac{1}{2}$ inches.

When battens are used they are fixed to coke breeze concrete fixing blocks to a gauge of $3\frac{1}{2}$ to 4 inches, but these will decay in time, and should not be used in consequence.

The most satisfactory method of fixing vertical tiling is shown at B, Fig. 297, where fixing blocks 9 by 5 by $1\frac{1}{4}$ inch are built into the wide joints on the face of the wall, the tiles being nailed to the blocks; and if they are ribbed they are hung from the projecting portion of the blocks.

Purpose made tiles are used for the internal and external angles of tile-hung walls, or else the angles are close-cut, with lead soakers inserted beneath the tiles to keep rain from penetrating.

Openings in Tile-hung Walls.—The tiles at the side of openings in tile-hung walls should be solidly bedded in cement, as shown at C, Fig. 297; and those above an opening should be tilted outwards by fixing the two lower courses to battens attached to tilting pieces fixed to the lintel over the opening, as shown at D, the lower course being a doubling course such as is used for eaves.

The sills of windows are usually formed as shown at

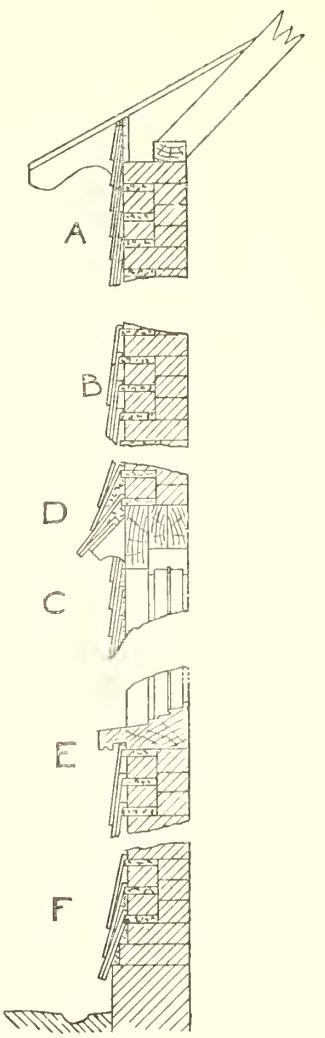


Fig. 297.

E, so that the course of tiles immediately below it can be nailed thereto, thus preventing the rain from driving up underneath.

When the tile hanging is carried down to the ground the lower course is tilted outwards, as shown at F, Fig. 297, a cement or stone channel being formed below to carry off the water which runs off the face of the tiles in very exposed situations.

CHAPTER XXIII

LEAD, ZINC, COPPER, AND ASPHALT ROOFS

(Contributed by T. H. Bishop, A.R.I.B.A.)

There are many circumstances which necessitate that roofs shall be flat, and covered with a material that is easy to handle and impervious to wet. Lead is generally used, and, when skilfully laid, makes an excellent job, and stands a considerable amount of traffic. Its range of expansion and contraction, however, makes it necessary that the work be well done.

Should the question of expense preclude the use of lead, zinc is the next material in favour. It is light, and the labour on it is not so expensive as that on lead. The noise made on it by the rain, and the ravages of the domestic cat, cause its use to be limited generally to the Speculative Builder.

Where cost has not to be considered, copper is an excellent roofing material. Its lightness, small range of expansion and contraction, and good appearance when oxidised, cause it to be used in the very best work.

The following table, taken from Sutcliffe's *Modern House Construction*, gives a comparison of copper, lead, and zinc :—

	Copper.	Lead.	Zinc.
Specific gravity	8.85 to 8.94	11.37	6.86 to 7.21
Atomic weight.	63	206.4	65
Weight per square foot $\frac{1}{16}$ in. thick .	4.6 lbs.	5.9 lbs.	3.7 lbs.
Melting - point in degrees Fahr. . . .	2012°	633°	773°
Conductivity (silver being 100) . . .	73.6	8.5	...
Linear expansion between 32° and 212° Fahr. . . .	.00171	.00285	.00297
Relative linear expansion .	58	96	100
Weight per square foot used for roofs	1 to 1⅛ lb.	6 to 8 lbs.	1 to 1½ lb.

Lead Flats form strong and impervious roof covering, and are well adapted for roofs subjected to great wear.

The woodwork on which lead is laid consists of joists or purlins, covered with boards at least 1 inch thick. The boards should be tongued, and laid in the same direction as the flow to prevent warping of the boards retarding the flow of water. In practice, however, the boards frequently have only their edges shot to form a close joint. Lead, owing to its expansion and contraction, must not be nailed to the boards, but be allowed free play. To permit of this freedom, wood or hollow rolls are used. These are usually 2 or 2½ inches diameter, nailed to the boarding and fixed from 1 ft. 6 in. to 3 ft. apart, but the divisions should never exceed 3 ft., and smaller ones are preferable. The maximum width of a sheet of lead is 7 ft. A sheet of this size can be cut into two strips each 3 ft. 6 in.

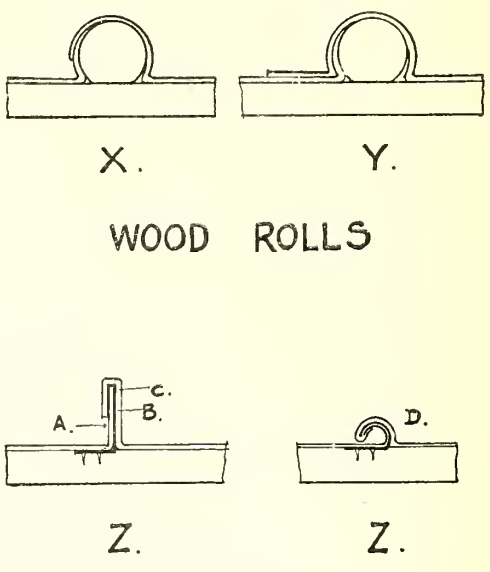


Fig. 298.

wide, so that if 3 in. is allowed along the edge of each sheet to form the overcloak on a 2½-inch roll, and 8 in. along the other edge is dressed up to form the overcloak and splash lap, the flat portion of the lead will be 2 ft. 7 in., the distance apart of the rolls 2 ft. 9 in. from centre to centre.

Fig. 298 shows three different forms of rolls, two of which, marked X and Y, are wood rolls ; the third, marked Z, is called a seam or hollow roll.

The seam or hollow roll is formed by dressing up one edge, marked A. Tacks or tingles of lead, or thin

copper, B, are then nailed to the boarding at intervals of from 3 to 4 feet, and turned over A. The edge of the sheet, marked C, is set up and turned over until it reaches half-way down the undercloak. The two edges are then dressed over, as shown at D, and finally bent to form a roll. Should lead tacks be used, sinkings should be made in the boards to receive them. Lead flats are usually laid to a fall of 1½ inch in 10 feet, but 2 to 3 inches in 10 feet is not excessive.

In some cases felt is used under the lead, but it is difficult to dress the lead on this material. At the upper end the lead is dressed over the roll and turned up 4 inches to receive the cover flashings, whilst at the lower end it is dressed over the end of the roll and

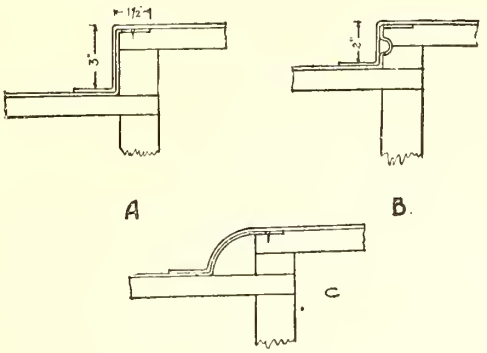


Fig. 299.

turned down 2 inches. As sheets of lead should never be laid in lengths exceeding from 7 to 9 feet, drips are necessary. These are formed in various ways, and should be from 2 to 3 inches deep; when made 2 inches, a groove should be formed to resist capillary attraction.

Fig. 299 shows the various forms of drips.

Nosings.—These are formed where the flats adjoin sloping roofs. A wood rounded nosing about 2 inches

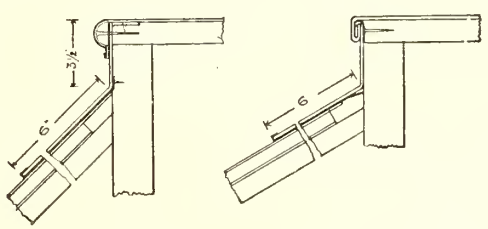


Fig. 300.

diameter is fixed on the left of the boarding, and the lead is dressed over and secured by lead clips.

Nosings may also be formed by a welted joint with copper clips the width of welt, and the two edges of the lead and copper welted together, and copper nailed (see Fig. 300).

Zinc Flats.—Zinc flats are used on account of lightness and economy; zinc having a small range of expansion and contraction as compared with lead.

The wood framing is formed in a similar manner to that for lead flats; the boarding should be deal (not oak), and the heads of the nails should be punched in.

Rolls, drips, and falls can be formed as in leadwork. The drips should be 2½ inches and 7 feet 6 inches apart. Drips are not required when the fall exceeds 1 in 8, the usual fall being 1 in 30.

The wall flashings should be finished with a bead to stiffen the lower edge, the upper edge turned 1½ inch into the wall and pointed in cement. The zinc for flats should be 14, 15, or 16 gauge, 14 gauge being only used in the cheapest work.

In laying zinc flats, the roll and cap system is the most general, the rolls being spaced 2 feet 10½ inches centre

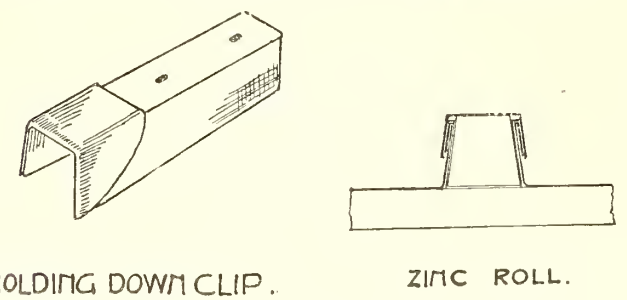


Fig. 301.

to centre. The sides of the zinc are turned up against the wood rolls in the width of the sheet, and the folding laps in the length. This method allows the sheets to expand and contract freely.

The wood rolls are covered with zinc caps, which are fixed by holding down clips (see Fig. 301).

In some cases the Italian corrugated method is used. This effects a great saving of cost in large spans, as the boarding can be dispensed with and the purlins fixed as far apart as 10 feet (see Fig. 302).

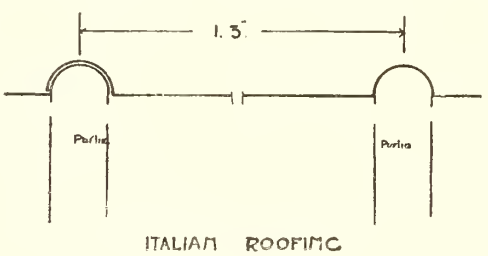


Fig. 302.

Copper Flats.—Copper is an excellent material for covering roofs, on account of its toughness, lightness, and durability, ready manipulation and small range of expansion and contraction, while it can be stamped, stretched, or hammered without damage. It can be laid with rolls in a similar manner to that described for zinc, the rolls being about 2 feet 4 inches centre to

centre. The caps should be welted to the sheets and left open at the sides to allow for expansion; and the saddles and stop ends welted in a similar manner.

This method of laying to rolls is preferable to the old method of welting, as the welts are damaged by traffic; and although the metal is practically unworn, the damaged welts necessitate the relaying of the roof.

When the sheets are welted, drips are unnecessary; but, if used, they can be as far apart as 15 feet.

The following is a table of gauges and weights of copper:—

B.W. Gauge.	Weights.	
	Per Square Foot.	Per Sheet.
	Lb. Oz.	Lbs.
20	1 12	14
22	1 6	11
24	1 0	8
26	13	6½
28	10	5
30	8	4

The best gauge for flats is 20 B.W., and for flashings and caps 24 B.W. gauge.

Asphalt Flats.

Besides the three methods of covering flat roofs already described, there yet remains another method, that of covering them with asphalt.

The advantages possessed by this material are economy, toughness, and durability; it is also non-absorbent, dries quickly after rain or being washed down, and is sanitary, non-flammable, vermin-proof, and easily cleansed, and is laid without joints or seams.

The concrete surface to be covered is finished with ¼ inch of cement rendering, finished rough with a wooden float or straight edge, for the reception of the asphalt.

Mastic asphalt is used; this is a bituminous lime stone prepared in the following manner:—

After being taken from the quarry it is ground to a fine powder and mixed with a proportion of fine grit, uniform in size and free from dust. After a thorough admixture it is placed in large fixed cauldrons and heated by strong fires. In order that the asphalt shall not calcine during this process, mineral tar is added as required, the whole mass being kept moving by machinery until the whole is reduced to a mastic. It is then run into moulds containing about 125 lbs., where it is allowed to cool, and the blocks are then removed.

There are three qualities of mastic:—

(1) Fine (containing no grit).
(2) Fine gritted.
(3) Coarse.

Qualities Nos. 1 and 2 are used for flats.

To prepare the blocks for laying, they are broken up and melted in cauldrons, from which the molten asphalt is taken in large ladles and spread over the cement screed (prepared for it) in two ½-inch thicknesses, each thickness screeded with a wooden screed, and the top layer finished with wooden hand floats to a smooth surface.

Where the flat adjoins a brick wall a vertical skirting 6 inches high and ¼ inch thick should be formed. The top of the skirting is turned 1 inch into a raglet cut into the brickwork to receive it. The top edge of the skirting should be slightly rounded, and angle fillets about 1½ inch wide should be formed to all internal angles of skirting and between the skirting and paving.

Channels can be formed in the asphalt as required, whilst the material is hot, leading to outlets as may be convenient.

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